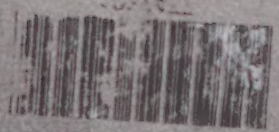
EASYWAVE®

WAVEFORM OPERATION SOFTWARE



LeCroy

Innovators in Instrumentation

ATL

OPERATOR'S MANUAL

EASYWAVE®
USER'S MANUAL
VERSION 2.0

July 1989

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LeCroy Corporation

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1 OVERVIEW

HOW TO USE THIS MANUAL

This manual is organized into ten sections and five appendices. First time users of *EASYWAVE* should review this manual in its entirety.

As you become accustomed to *EASYWAVE* and a LeCroy Arbitrary Function Generator, however, you will notice that the main body of the manual can be looked at as being divided into five main areas of interest:

1. Introduction – Sections 1 and 2
2. Installation and Startup – Section 3
3. How *EASYWAVE* Works – Sections 4 and 5
4. Principal *EASYWAVE* Operating Modes – Sections 6, 7, 8, and 9
5. Examples of How To Use *EASYWAVE* – Section 10

A "Quick-Start" operating summary is provided in Section 1.3, along with waveform creation guidelines. This summary provides a quick review of procedures which are described in greater detail in Sections 4 and 5.

Appendix A provides help screens that describe most *EASYWAVE* operations. Appendix B contains instructions for use of the CATWAV (CATALYST-TO-EASYWAVE) file conversion utility. Appendix C shows how to use noise in creating waveforms. Appendix D summarizes GPIB commands to a LeCroy Arbitrary Function Generator used in Sequence files, described in Section 7. Appendix E describes the use of Step and Pulse in creating waveforms.

KEY FEATURES

LeCroy's *EASYWAVE* Software allows the user to access the full capability of any LeCroy Arbitrary Function Generator (AFG). *EASYWAVE* facilitates creating, editing, and generating waveforms. In addition, it provides flexible operation in conjunction with waveforms captured and analyzed from other sources by any LeCroy oscilloscope. The key features of *EASYWAVE* are summarized as follows:

Creating and Editing Waveforms. Waveforms can be quickly created in the *EASYWAVE* software, then sent directly to the file memory (non-volatile RAM disk) of a LeCroy AFG for storage. These waveforms can subsequently be recalled and edited as required.

Waveforms can be created and/or edited via *EASYWAVE* in any combination of six ways: equation entry, array entry, constant entry, block actions, simple waveform element selection, or transfer from a LeCroy Oscilloscope.

Storing Waveforms. *EASYWAVE* software allows the storage of waveforms on disk or in the AFG in single channel or dual channel mode (if the AFG is a dual channel AFG). Data acquired from a LeCroy Oscilloscope (scope) can likewise be stored to disk or sent to the AFG with or without being edited.

Automatic Execution of Stored Command Sequences. The AFG can be programmed through the use of Sequence files that operate in much the same fashion as a batch file or command file. *EASYWAVE* allows the creation, editing, and execution of Sequence files.

Standard Function Generator and Pulse Generator Modes. The AFG can be operated as a standard function generator or pulse generator directly through the *EASYWAVE* menus.

Flexible Waveform Display Modes. *EASYWAVE* provides the user with a variety of waveform display options. In dual channel mode, for example, two waveforms can be viewed separately, superimposed on one another or in a dual screen mode as on an oscilloscope. When editing an array of data, the waveform portion being edited is displayed as an inset on the screen. Other display options include zoom and both horizontal and vertical waveform scrolling.

EASYWAVE QUICK START

The following is a quick reference to more detailed instructions in Section 3.

Here and throughout the remainder of this manual, the description of each operation is presented as an *EASYWAVE* tutorial in an action–response format. User actions, shown within square brackets [ ], define inputs that must be typed into the computer. These brackets are not to be typed; only the text between the brackets need be typed.

NOTE:

1. Square brackets may sometimes appear within EASYWAVE menus, where they enclose default values, in these cases they will appear within framed figures in this manual and do not represent user inputs.

2. EASYWAVE is NOT generally case–sensitive and there is no need to capitalize letter entries. Exceptions are for unit prefixes such as m for milli and M for Mega, and commands such as z for zoom out, and Z for zoom in.

Installation (See Section 3 for detailed instructions)

1. Install the National Instruments GPIB Adapter into the computer.

2. Copy GPIB.COM, supplied with the PC-2 GPIB Adapter, into the root directory.
3. Add DEVICE=GPIB.COM to the config.sys file in the root directory.
4. Set the LeCroy AFG to GPIB address 1, using the rear panel GPIB switches.
5. Connect the AFG to the computer using GPIB cables.
6. Install *EASYWAVE* on PC hard disk by inserting Disk #1 into the A drive, typing [A:], and pressing the [Enter] key.
7. Type [INSTALL] followed by pressing the [Enter] key.
8. The Install program will prompt the user for the necessary information. Follow the instructions on the PC screen.

Startup (See Section 3 for detailed instructions)

1. From the EW directory, type [PRTSCRN] and press the [Enter] key to enable the screen print utility.
2. From the EW directory, type [EW] and press the [Enter] key.

Running EASYWAVE (See Sections 5 through 10 for detailed instructions)

1. *EASYWAVE* is a menu-based program. The system menu displays the major operating mode selections:

   Configure: Select GPIB addresses and other parameters.

   Edit: Create or modify Waveform, Settings, or Sequence files.

   File transfer: Move files between *EASYWAVE*, AFG, Scope and/or Disk.

   Operate: Control the AFG.

   Selection of the desired menu item is made by typing in the letter capitalized in the desired menu selection.
2. The [F1] function key displays a list of available HELP screens. Use cursor keys and [Enter] to select. Help screens appear automatically unless disabled from the Configuration menu.
3. The Help screen KEY.HLP describes the use of the [Esc] and Function Keys, [F1] through [F6] in selecting menus.
4. The Cursor Keys, including [Home], [End], [PgUp], and [PgDn], and the other Special Keys, [z], [Z,] [<], [>]

and [Ctrl], related to the waveform display are explained in the WAVEDISP.HLP Help screen.

NOTE: A listing of all help screens is found in Section 5, and a printout of each help screen can be found in Appendix A.

WAVEFORM CREATION GUIDELINES

EASYWAVE is an easy-to-use software package that creates Waveform data files, Sequence files and Settings files which, after being transferred into a LeCroy Arbitrary Function Generator, are used to generate custom waveforms.

Waveform files contain a series of data points which represent the normalized amplitude of the waveform, specified to 8,12 or 16-bit digital resolution. A series of data points comprising a waveform segment may be combined with other such segments using the link operation. Alternatively, waveforms may be formed by repeating individual segments, by repeated linking, or by different combinations thereof.

The data samples within these waveforms are scaled in amplitude and time by the factors contained in the settings file to produce the desired waveform. The following list summarizes important characteristics of the waveform generation process.

1. In continuous trigger mode and without linking, a single waveform must contain a multiple of four data points (a multiple of eight for an 8-bit AFG). Dual waveforms require a multiple of two data points each (four for an 8-bit AFG).
2. In any trigger mode other than continuous mode, or if linked, the minimum waveform segment length required is 36 data points (72 for an 8-bit AFG). For dual channel mode the minimum length is 18 data pints (36 for an 8-bit AFG).
3. Each segment may be repeated up to 4095 times.
4. There can be up to 681 linked waveform segments.
5. The maximum waveform length is 32,768 (32K) samples. For an 8-bit AFG the maximum length is 65,536 samples (64K).
6. The entire waveform may be repeated up to 65,535 times.
7. Phase continuous output requires that the wave segment contain an integral number of cycles of an element.

8. Absolute calibration of the waveform cursor readouts requires that the settings menu in the Edit mode contain the desired values. These values should be saved to disk and to the AFG as a settings file.
9. Dual waveforms are displayed in the *EASYWAVE* editor but only the Channel 1 display may be modified. The swap menu selection is used to exchange waveforms between Channels 1 and 2, thereby permitting both waveforms to be edited.

EASYWAVE SPECIFICATIONS

Waveform Creation and Acquisition

To be generated by the LeCroy Arbitrary Function Generator, waveforms may be created directly or captured from a LeCroy Oscilloscope. Utility programs are also provided for transforming LeCroy CATALYST® Transient Recorder or Digitizer data files into *EASYWAVE* formats.

Waveform Creation Tools

Simple Elements – select and build complex waveforms using any of eight simple waveform segments including:

Sine	Ramp	DC/Step
Square	Exponential	Gaussian Pulse
Damped Sine	Frequency Sweep (Linear or Logarithmic)	

Amplitude, frequency, time and phase attributes of each simple element are user adjustable.

Equation Entry – create waveform by direct entry of analytic equation. Permitted operations are addition, subtraction, multiplication, division, and exponentiation. Functions supported are Absolute Value, Cosine, Sine, Exponent, Common Logarithm, Natural Logarithm, Sine, Square Root, and Tangent. Parentheses for specifying the order of operations and serial operations are available.

A special noise variable is used to add random noise to waveforms, see Appendix C. Step and pulse can also be used, see Appendix E.

Data Acquisition Tools – Direct Transfer of waveforms from either channel of a LeCroy Oscilloscope.

CATWAV utility program for converting CATALYST data files.

Waveform Editing

Array – Direct operations on individual data point values, including insertion (in decimal, hexadecimal or binary), deletion, increment and decrement.

Block Actions – Insert, delete, or modify groups of data points (Blocks). Data blocks may be transferred from or to

Disk. Modifications include horizontal or vertical scaling and vertical movement (offset).

Sequence File Generation and Editing

Generate and edit Sequence files for automating a series of AFG control and/or operational commands. Transfer Sequence file to or from Disk files or the AFG.

Settings Files

Modify, Store, and Recall AFG control settings. Transfer Setting files between *EASYWAVE*, the AFG, and/or Disk. Get some settings from a LeCroy Scope.

File Transfer

Transfer Waveform, Sequence, and Settings files between *EASYWAVE*, the AFG, the Scope and disk. Delete selected files. Select and List file Directories in the AFG or from Disk.

Function Generator Operations

Control the AFG as a Function, Pulse, or Arbitrary Function Generator. Select, load, link, and loop desired waveforms. Start, stop, arm trigger, trigger, advance to next, or abort output waveforms. Set the output parameters of each channel including Amplitude, Offset, and Filter cutoff frequency. Turn each channel on or off, sum or invert output channels. Adjust Clock period or frequency, pulse width, start phase or relative phase of outputs. Select trigger modes, trigger slope/level, and trigger source.

Configure Interface

Set *EASYWAVE* configuration. Select GPIB address and name, Afg address and type, Scope address and type, DMA on or off, Help on or off and colors if color monitor.

Physical Description

EASYWAVE is supplied on three double-sided, double-density (360 kbyte formatted) 5 1/4 inch disks (3 1/2 inch disks are available upon request), including an Installation and Runtime Support disk, *EASYWAVE* Program disk, and a Waveform Sample/Utility disk.

EASYWAVE runs on IBM XT/AT computers and 100% compatible computers with a hard disk drive, 640 kbytes of random access memory, and a color graphics, enhanced graphics, or Hercules monochrome graphics adapter. It requires a National Instruments PC2 or PC2A GPIB Adapter and associated software support package (not supplied) to control the LeCroy Arbitrary Function Generator or to get files from the LeCroy Oscilloscope. See Section 3 for more details.

Note: We recommend that the GPIB Driver software be Rev. C.7 or later. If you are using a PC2A adapter with an earlier driver, it may be necessary to turn DMA off for files to be transferred properly.

2 REQUIREMENTS

HARDWARE

In conjunction with a LeCroy Arbitrary Function Generator and the optional use of a LeCroy Oscilloscope, *EASYWAVE* will run on an IBM AT/XT or 100% compatible computer equipped with DOS 2.0 or higher and the following hardware:

a. 640 kilobytes of available memory

b. 10 megabyte or larger hard disk drive

c. National Instruments PC2 or PC2A GPIB interface adapter

d. Color Graphics Adapter (CGA), Enhanced Graphics Adapter (EGA), or Hercules Graphics Adapter (HGA)

SOFTWARE

EASYWAVE software consists of three 5 1/4" floppy disks:

1. Installation and Runtime support disk
2. *EASYWAVE* program disk
3. Waveform sample/utility disk

Copies of these disks can be made to cover possible hard disk problems.

Note: 3 1/2 inch diskettes are available upon request.

3 INSTALLATION

INSTALLING EASYWAVE

1. Put *EASYWAVE* disk #1 into drive A and type [A:] followed by [Enter]. To load the INSTALL program type [INSTALL] again followed by [Enter]. Respond to prompts as they are displayed on your PC screen. The installed program will create \EW and \CATWAV directories, if necessary, and files will be transferred to those directories on the hard disk.

2. If it is desired to run a LeCroy AFG or to get files from a LeCroy Scope:

   a. Install the National GPIB board.

   b. Make a CONFIG.SYS file with DEVICE=GPIB.COM or add DEVICE=GPIB.COM to existing CONFIG.SYS file in the root directory. A sample CONFIG.SYS file follows:

      ```
      files=20
      buffers=15
      DEVICE=GPIB.COM
      ```

   c. The National Instruments GPIB program files, supplied with the GPIB adapter card, GPIB.COM and IBCONF.EXE supplied with the National GPIB Adapter card should exist in the root directory of the computer.

   d. Connect a GPIB cable between the PC and the AFG and/or the Scope.

   e. Configure the GPIB switch on the rear panel of the AFG as follows:

      i. GPIB interface selected (GPIB switch section 3 set to 1)

      ii. Set the GPIB address to 1 (the *EASYWAVE* default value).

   f. Configure the GPIB address switch on the rear panel of the Scope to address 04, the EASYWAVE default value.

3. If you intend to print waveforms from *EASYWAVE* you must load the utility program PRTSCRN.EXE each time you start *EASYWAVE*. PRTSCRN is loaded from the EW subdirectory as shown below:

   a. Type: [PRTSCRN.] and then [Enter]. After loading the utility, the computer will display the message:

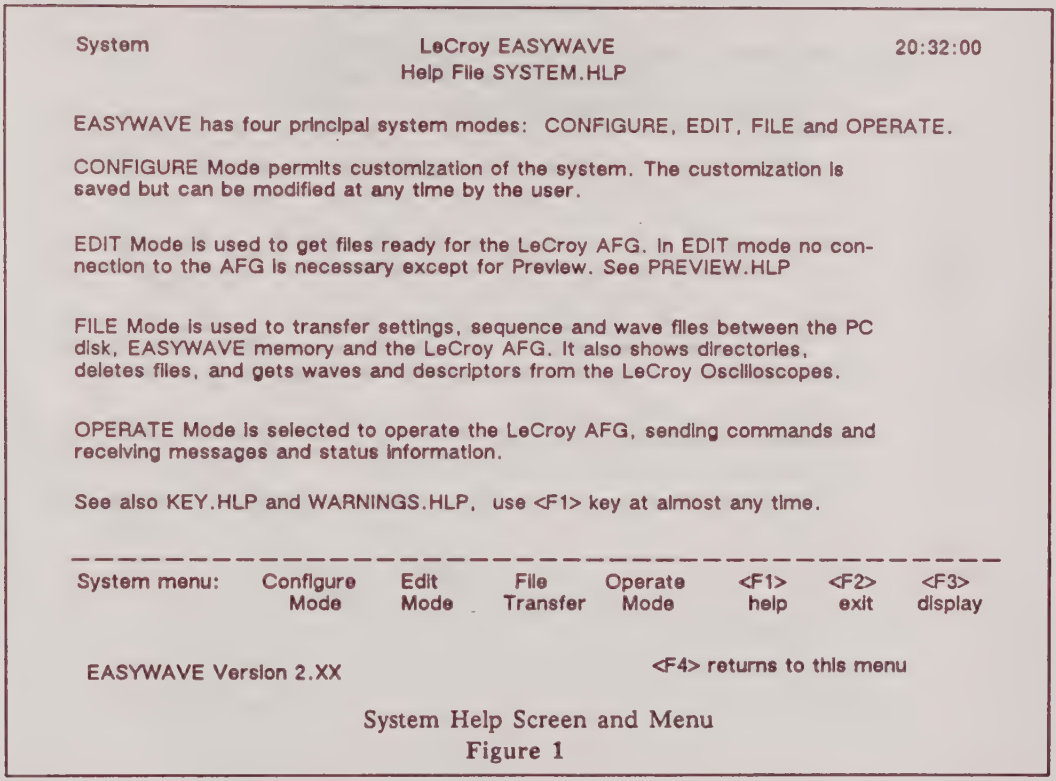
MetaWINDOW Print Screen Utility Installed ...

b. Once the Print Screen utility is installed any display can be printed to a dot matrix printer by pressing the [Shift] and [PrtSc] keys.

NOTE: On some compatible computers such as the Compaq 386 only the Print Scrn key need be pressed to initiate printing.

RUNNING EASYWAVE

Start *EASYWAVE* from the EW subdirectory by typing [EW] and then by pressing the [Enter] key. The display shown in Figure 1 will appear on your computer screen.


System
LeCroy EASYWAVE
Help File SYSTEM.HLP
20:32:00
EASYWAVE has four principal system modes: CONFIGURE, EDIT, FILE and OPERATE.
CONFIGURE Mode permits customization of the system. The customization is saved but can be modified at any time by the user.
EDIT Mode is used to get files ready for the LeCroy AFG. In EDIT mode no connection to the AFG is necessary except for Preview. See PREVIEW.HLP
FILE Mode is used to transfer settings, sequence and wave files between the PC disk, EASYWAVE memory and the LeCroy AFG. It also shows directories, deletes files, and gets waves and descriptors from the LeCroy Oscilloscopes.
OPERATE Mode is selected to operate the LeCroy AFG, sending commands and receiving messages and status information.
See also KEY.HLP and WARNINGS.HLP, use <F1> key at almost any time.
System menu:
Configure Mode
Edit Mode
File Transfer
Operate Mode
<F1> help
<F2> exit
<F3> display
EASYWAVE Version 2.XX
<F4> returns to this menu

System Help Screen and Menu
Figure 1

This is the typical *EASYWAVE* "power-up" display screen. The menu here (and elsewhere) is located beneath a dotted line near the bottom of the screen. Above the dotted line is descriptive text that explains the individual menu items. That text is the "System" help screen.

NOTE: In some computer configurations, the display hardware may not be correctly recognized by the program and a blank or unreadable display may result. In this case, type:

[EW 6] and then press the [Enter] key if you are using a Color Graphics Adapter

[EW 8] and then press the [Enter] key for Hercules Graphics,

[EW 560] and then press the [Enter] key for EGA enhanced (640×350) display.

CGA displays will use high resolution monochrome mode. High resolution color displays require the use of an EGA adapter and a high resolution (640×350) display.

4 MENU STRUCTURE

EASYWAVE MENU STRUCTURES

EASYWAVE is accessed and implemented through several menu levels. Menu choices at each level are for the most part self explanatory. For additional detail on the workings of *EASYWAVE*, however, the user can always use the [F1] key to access any of the "help" screens that explain particular menus, functions, or operations in detail.

Figure 2 is a menu tree showing the contents of the principle *EASYWAVE* menus and sub-menus. Each menu item is either self explanatory and/or is defined in greater detail in the help screens listed in Section 5 and shown in Appendix A.

Appropriate help screens are designed to appear automatically when operational menu selections are made for the first time after reboot. When automatic help is no longer wanted, it can be disabled in the Configure mode. All help screens, however, can always be accessed via the [F1] key.

As shown in Figures 1 and 2, the *EASYWAVE* system menu offers a selection of function key options, plus four main mode selections, each of which has one or more menus.

EASYWAVE ACTION MODES

Configure

The configuration of *EASYWAVE* is set in this menu, where a user can select GPIB adapter name and address, and the type and GPIB address for the AFG and Scope. Also in this menu is the capability to join waveform generation dots or to show them discretely; the ability to disable and re-enable automatic help screen display; a direct memory access (dMa) disable necessary for operation with some PC clones; and color selection for use with color monitors.

NOTE: The color selection menu does not appear when EASYWAVE is used with a monochrome graphics adapter or color graphics adapter (CGA).

Edit

The Edit mode allows the creation and editing of Setup Files, Sequence files, and Waveform files. The AFG need *not* be connected to the GPIB during edit mode unless previewing is desired. See PREVIEW.HLP.

In Edit mode, waveforms can be calculated and displayed on your PC screen, but these waveforms are *not* executed by the AFG until they are first transferred to AFG memory by means of the File Transfer mode, and then loaded and executed by means of the Operate mode.

File Transfer

A file created or edited in Edit mode resides only in *EASYWAVE* memory until it is transferred to PC disk for storage or to the AFG for storage or execution. Similarly, a file in AFG or PC disk memory must be transferred to *EASYWAVE* before it can be edited.

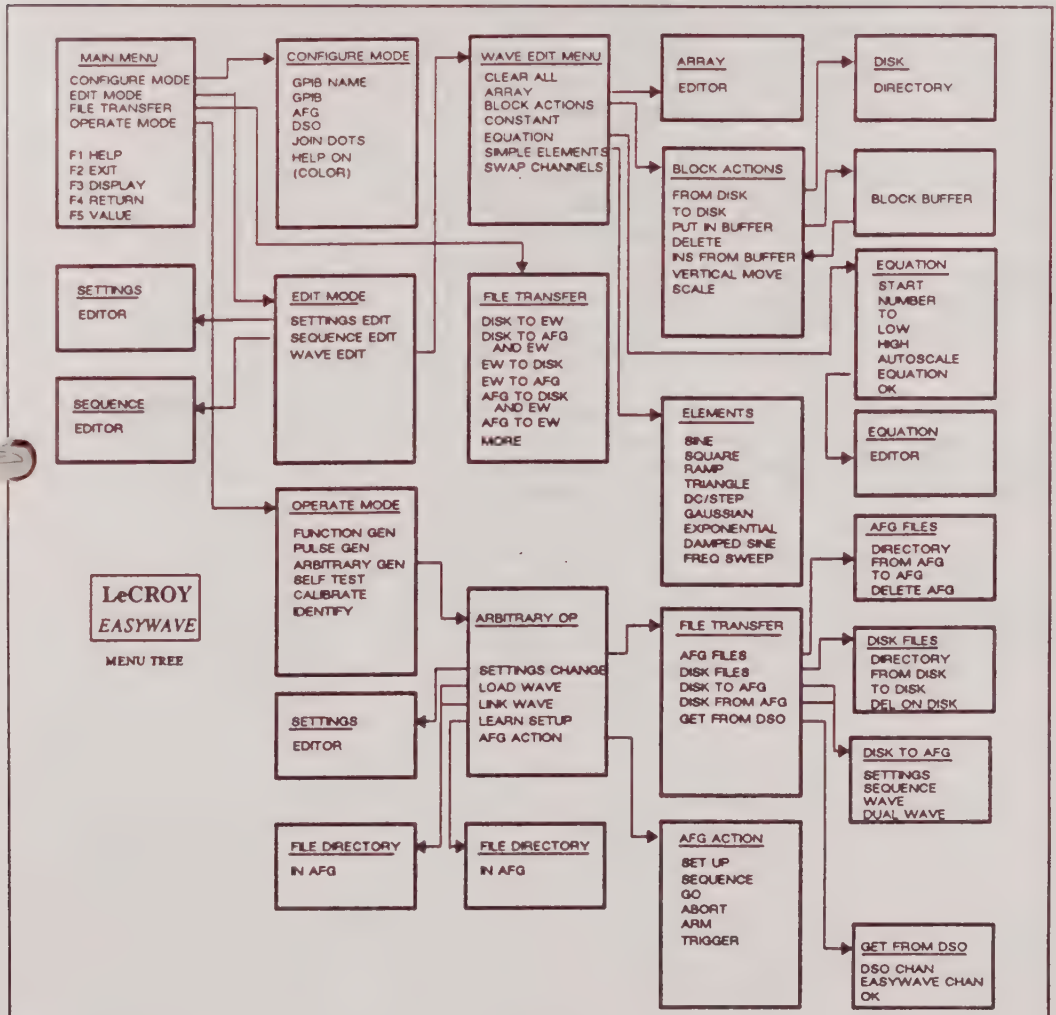


Figure 2

NOTE: Arbitrary waveforms must be edited in the Edit mode, but channel settings can be edited either in the Edit mode or in the Operate mode. See Section 9 for details on editing settings in the Operate mode.

Accordingly, the File Transfer mode is used to transfer setting, sequence, and/or waveform files to and from PC disk, the AFG, and EASYWAVE. Other file transfer actions include deleting files in the AFG or on PC disk, obtaining directories of files stored on PC disk or in the AFG, and getting waveforms and file descriptions from a LeCroy Scope.

File transfer is accessed from any of the other main modes by first pressing [F4] to return to the system menu, and then by pressing [F] for file transfer.

NOTE: The LeCroy AFG needs to be connected during File Transfer only if files are being transferred to or from the AFG. File transfer between EASYWAVE and your PC's disk does not require the AFG to be connected.

Operate

The Operate mode is used to control the LeCroy AFG to run as an arbitrary function generator, a standard function generator, or a pulse generator. Other utilities provided in the Operate menu include calibration, AFG self-test, and AFG identification.

NOTE: Standard sine, square, triangle, ramp, DC, and pulse waveforms may be specified and executed entirely within the Operate main menu. The edit and file transfer modes are not necessary for standard waveforms created and executed using the Operate main menu.

INFORMATION ENTRY

Prompted information required for entry into *EASYWAVE* is either self–explanatory, described in a help screen, or explained in this manual. The following notes will help to understand *EASYWAVE* prompts and the manner in which numbers and units must be entered.

a. To select a menu item, press the capitalized letter (or number) for that item.

b. When the name of a menu category is shown in parentheses, that category is not available for entry.

c. Whenever a number is requested, its limits are shown in parentheses ( ) and its current value in brackets [ ].

d. Units need not be entered. Default units are volts, seconds/point, points/sec and Hz. M, K or k, m, U or u and N or n can be used for mega, kilo, milli, micro, and nano respectively. Spaces are ignored e.g.:

for 31 mV: 3.1e–2, 31m, 31 m, 31 mV, or .031
for 12 nsec/pt: 12e–9, 12n, 12 n, 12 nS
or 0.000000012
for 123 Mpts/sec: 123e6, 1.23e+8, 123M, 123 M,
123 Mp or 123000000

e. Whenever the intent is clear, a number will be accepted without a menu selection, *e.g.*, for value in general. A notable exception is the entry of negative numbers which require a menu selection.

WAVEFORM AND CURSOR DISPLAY CHANGES

EASYWAVE has been designed to allow a great deal of flexibility in moving the cursor and displayed waveform on your computer screen. The keyboard actions necessary to achieve such movements are:

[Home]	First page of wave, cursor at first point
[End]	Last page of wave, cursor to last point
[PgUp]	Previous page of wave, cursor one page towards beginning
[PgDn]	Next page of wave, cursor one page towards end
[←]	Move cursor one point to left
[→]	Move cursor one point to right

NOTE: Holding the [Ctrl] key at the same time as the right or left arrow keys will cause the cursor to move faster.

[↑]	Move wave one point towards top of screen if expanded in zoom mode (see Z below)
[↓]	Move wave one point towards bottom of screen if expanded in zoom mode (see Z below)
[<]	Fewer points of wave shown on a page
[>]	More points of wave shown on a page
[Z]	Zoom wave in, expand (magnify) vertical scale
[z]	Reduce/eliminate zoom

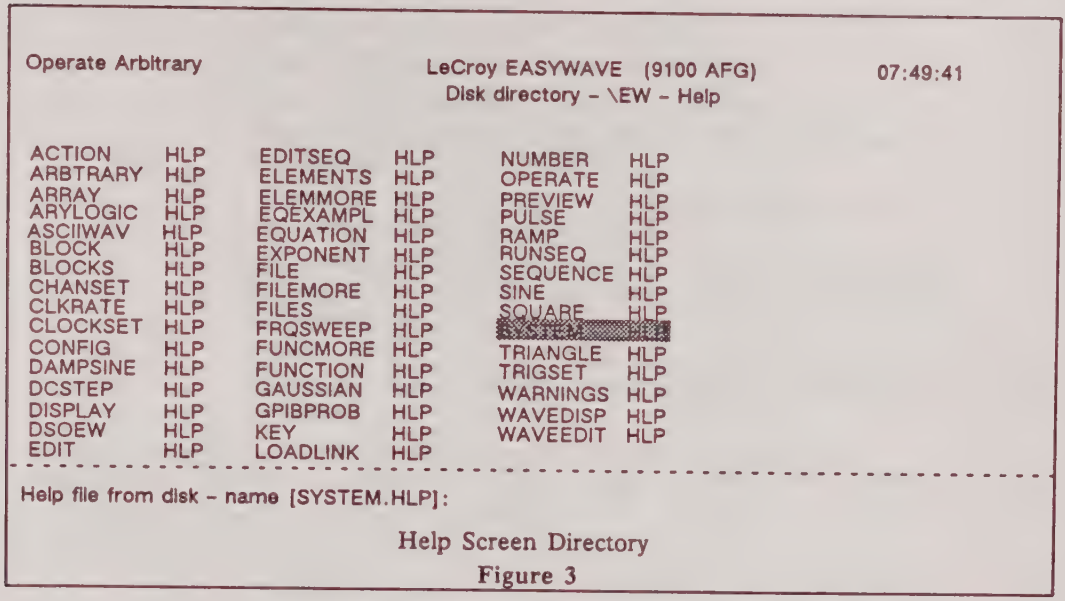
NOTES:

1. *The movements described above are only for cursor and waveform display on your PC screen. These will not affect the waveform data in any way.*
2. *The display cursor readouts, corresponding to the amplitude and horizontal location of the cursor, appear below the control menus. Pressing any cursor control key will update the cursor readout. Pressing the [Ins] (Insert) key will recall the cursor readout without affecting the cursor location.*

FUNCTION KEYS

Six function keys are used in *EASYWAVE*:

[F1] enables display of a "help" screen directory, Figure 3.

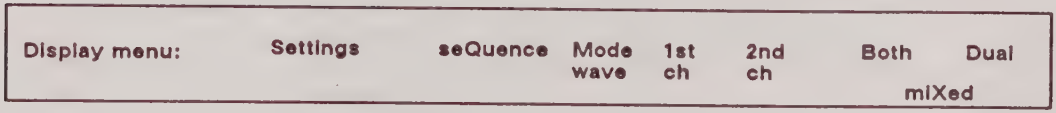


Help Screen Directory

Figure 3

[F2] will, when pressed, return control to the principle menu in which *EASYWAVE* had been working. A principle menu is defined as the configure, edit, or file transfer main menus, or the function generator, pulse generator, or arbitrary generator submenus in the Operate mode. Pressing [F2] from any of these menus will return control to the System menu.

[F3] allows choice of the display. It can be accessed at any time, from any menu. The menu will appear as follows:



where:

Settings (selected by pressing the [S] key): This selection brings up a display of the current settings file.

seQuence (Q): displays the current sequence file. If no sequence file is current in *EASYWAVE*, the message "No sequence file in memory" will be displayed.

Mode: toggles between wave and logic.

1st ch (1): displays the Channel 1 waveform

2nd ch (2): displays the Channel 2 waveform

Both (B): shows both waveforms (Channel 1 and Channel 2) overlayed in the same display.

Dual (D): displays Channel 1 waveform above Channel 2 waveform in a split screen mode.

miXed (X): Displays upper 12 bits of channel 1 in analog form and lower 4 bits in logic mode – mode toggles between upper and lower displays.

When the 1, 2, B, D or X selection is made, the selected waveform area is displayed, accompanied by a submenu as follows:

Display wave:	Offset	Cursor	(value)	duratIoN	Mode	1st	2nd	Both	Dual
	0	0	(128)	1200	wave	ch	ch		
	(0.000 s)	(0.000 s)	(196 mV)	(6.000 us)					

where:

Offset (0): Allows choice of the starting point of the display.

Cursor (C): This selection provides for directly setting the horizontal position of the cursor. An alternate method is using the arrow keys described in Section 5.

(value): This item is non-selectable. It always shows the vertical value of the current cursor location.

duratIoN (N): This selection allows you to set the horizontal length of the on screen display. When it is selected, a prompt asks for the length desired. The possible range is shown in parentheses.

Any number within the range may be entered for N, but *EASYWAVE* will round any entered value up to a specific number of displayed points as follows: 50, 60, 75, 100, 120, 150, 200, 300, 600, and any whole number multiple of 600.

The combination of Cursor and value shows the horizontal point number and vertical count for the current cursor location. Also shown for each of these is the calculated time from zero point to the cursor, and the calculated voltage for the cursor location. Remember that the calculations for these values are based on the settings in the current settings file.

NOTES: 1. Both levels of the F3 display menus have identical "Mode 1st ch, 2nd ch, Both, and Dual" options. Accordingly, if you use F3 and choose to display the Channel 1 waveform, you can directly switch to the Channel 2 waveform, a dual display, or an overlayed (both) display at any time.

2. If no wave is in the selected channel, the screen will say that no points are in a wave for that channel, and the cursor field will be inaccessible.

[F4] causes display of the system menu shown in Figure 1. As explained in Section 4, the help screen shown above the menu in Figure 1 will appear only under specific circumstances, but pressing [F4] will make the system menu available from any other location within *EASYWAVE*.

[F5] toggles to switch waveform amplitude and position information from data value and point number to volts and seconds, and back again. Default setting is volts and seconds.

[F6] allows preview of waveforms and sequence files in Edit Mode. It is discussed at length in Appendix E.

HELP SCREENS

All help screens are either shown automatically (unless automatic display is disabled in the Configure mode) or referenced in an automatic screen. Notice in Figure 3 that upon being first displayed after pressing [F1], the entire first listing of the help directory is backlit. The location of that backlighting is controlled by the cursor keys on your keyboard.

Any help screen can be displayed simply by pressing the [Enter] key while the backlighting is over the name for that help screen. Alternatively, a help screen will be displayed if its name is typed in and the [Enter] key is pressed.

All *EASYWAVE* help screens are shown in Appendix A of this manual. The help screen designations and their definitions are listed below in alphabetical order:

ACTION HLP lists instrument actions that can be invoked in the Operate mode.

ARBTRARY HLP discusses the submenu obtained by going into Operate mode and then into the listing entitled "Arbitrary generator".

ARRAY HLP explains Edit Wave Array editing in wave mode.

ARYLOGIC HLP explains Edit Wave Array editing in logic mode.

ASCIIWAV HLP explains using ASCIII .DAT files to input waves into EASYWAVE.

BLOCK HLP shows how block editing works in the Edit mode.

BLOCKS HLP gives more information about block editing.

CHANSET HLP defines channel setting parameters.

CLKRATE HLP explains which clock rates are attainable.

CLOCKSET HLP defines the clock setting parameters.

CONFIG HLP defines the items listed in the Configure menu.

DAMPSINE HLP provides information about specifying damped sine waves in the simple elements portion of the wave edit menu.

DCSTEP HLP offers details on specification of DC/step waveforms in the simple elements portion of the wave edit menu..

DISPLAY HLP lists the display menu options available after pressing [F3]

DSOEW HLP explains the "Get from DSO" option contained within the second part of the File transfer main menu.

EDIT HLP describes the Edit mode main menu.

EDITSEQ HLP explains the options available for sequence editing.

ELEMENTS HLP identifies the types of simple element editing allowed in the Edit mode.

ELEMMORE HLP gives information about the second portion of the simple element help screens.

EQEXAMPL HLP gives examples of equations.

EQUATION HLP provides information about equation entry.

EXPONENT HLP explains the parameters involved in specifying exponential waveforms in the simple elements portion of the wave edit menu.

FILE HLP identifies file transfer menus.

FILEMORE HLP explains the "More" command on the File Transfer menu.

FILES HLP gives information about file types.

FRQSWEEP HLP defines the parameters that must be selected in specifying frequency sweep waveforms in the simple elements portion of the wave edit menu.

FUNCMORE HLP identifies lower level function generator menu in the Operate mode.

FUNCTION HLP defines the function generator menu in the Operate mode.

GAUSSIAN HLP defines the parameters unique to specification of Gaussian waveforms in the simple elements portion of the wave edit menu.

GPIBPROB HLP gives suggestions on what do do if *EASYWAVE* encounters a problem in communicating with the AFG.

KEY HLP is a reminder about which keys perform which tasks.

LOADLINK HLP explains the load and link capabilities that are a part of the arbitrary generator waveform menu within the Operate main menu.

NUMBER HLP shows how numbers are entered in *EASYWAVE*.

OPERATE HLP describes the options provided by the Operate main menu.

PREVIEW HLP discusses preview of wave and sequence files in Edit Mode.

PULSE HLP lists the pulse generator submenu in Operate mode.

RAMP HLP identifies the parameters involved in specifying a ramp waveform in the simple elements portion of the wave edit menu.

RUNSEQ HLP explains the options available when running a sequence file.

SEQUENCE.HLP discusses sequence files.

SINE HLP provides information about specifying sine waves in the simple elements portion of the wave edit menu.

SQUARE HLP defines the parameters used in the specification of square waves in the simple elements portion of the wave edit menu.

SYSTEM HLP describes the system menu.

TRIANGLE HLP offers information about the specification of triangle waveforms in the simple elements portion of the wave edit menu.

TRIGSET HLP lists the trigger and delay setting capabilities.

WARNINGS HLP indicates important points to be aware of.

WAVEDISP HLP lists the specific keys used to move the cursor and modify the wave display.

WAVEEDIT HLP enumerates the ways by which a wave can be changed.

A copy of each help screen is shown in Appendix A, in the same alphabetical order used above to define the help screen designations.

THE [ESC] KEY

When pressed, this key will cause upward movement on the *EASYWAVE* menu tree shown in Figure 2. To illustrate this operation, suppose the system menu is displayed (press [F4] to show the system menu if it is not currently being shown on your computer screen). If you then press [C] (for Configure), the configure menu will appear as shown in the menu tree. Press [Esc] at that point, however, and the system menu will reappear.

In using [Esc], [F2], or [F4] to move up the menu tree, note that only the menu and the system mode readout in the upper left corner of the display change. The contents of the display above the menu may not change.

When the system menu is shown and the [C] key is pressed, the Configure menu appears. The selections in that menu are shown beneath the dotted line in Figure 4, with the CONFIGURE help screen shown above that dotted line.

```
Configure                    LeCroy EASYWAVE                    07:54:05
                             Help File CONFIG.HLP

Menu in CONFIGURE Mode
   Gpib        the GPIB address for the PC to use, default = 0.
   Name        the name of the GPIB board, default GPIB0, other GPIB1.
   Afg         the GPIB address of the LeCroy AFG, default = 1.
   Type        Selects AFG Model. If 9101 AFG, no channel 2 settings needed. If No
               AFG, allow menus in Operate mode without any AFG connected. Also
               selects 12 or 16-bit data form for 9112 AFG.
   Scope       the GPIB address of the LeCroy Scope, default = 4.
   tYpe        9400, 9420, 9450 or No Scope. No Scope allows
                 Get from Scope menu without any Scope.
   dMa         default is as set in GPIB.COM using IBCONF. Can be turned
                 off in EASYWAVE if PC2A board or PC clone needs it off.
                 If (dma) then DMA is turned off in GPIB.COM and cannot be
                 turned on in EASYWAVE. Returns to GPIB.COM setting
                 when leave EASYWAVE.
   Join dots   If yes, join data-point dots together with lines.
   Help        If on, get automatic help screens first time in any menu.
   Colors      If color display, select colors.
These changes are saved on disk, so permanent until further change by user
-------------------------------------------------------------------------
Configure:  Gpib   Name   Afg  Type     Scope  tYpe    dMa   Join dots  Help  Colors
              0    GPIB0    1  9112         4  9420    off       on      on
                              12-bit          Scope
```

Configure Menu and Help Screen

Figure 4

As is the case with all *EASYWAVE* menus, press the capitalized letter.

Pressing [A] when the Configure menu is displayed as shown in Figure 4, for example, will result in a menu that says:

```
Configure AFG address (0 to15) [1]:
```

Entering any number (pressing the appropriate key and then the enter key) between 0 and 15 will then complete entry of the AFG address. A warning message will appear if the address entered is not unique.

NOTE: The "color" menu selection will not appear on screen if a monochrome monitor is being used.

EDIT MODE

EDIT MODE

The edit mode is used for creation of waveform files, settings files, and/or sequence files. Files that have previously been stored on disk or in the AFG can be changed in the Edit mode after being transferred to *EASYWAVE* (EW) via the file transfer mode (see Sections 8 and 10).

The AFG does not have to be connected to your computer when *EASYWAVE* is in the Edit mode. One must, however, keep in mind that no more than one waveform file can be edited at any one time in *EASYWAVE*. The same applies to settings files and sequence files.

The Edit mode is selected by pressing [E] when the system menu is displayed. The editing menu will then appear as follows:

Edit mode:	Settings edit	seQuence edit	Wave edit

SETTINGS EDIT

This selection brings up a display listing of the parameters that can be controlled on the LeCroy AFG. Setting parameters are for the Channel 1, Channel 2, Clock, Trigger, and delay values in accordance with the following:

Settings For Channel 1 and Channel 2:

Amplitude: Peak to peak amplitude, from 5.00 mV to 10 V for 9100, 9101 or 9109; from 76 µV to 10 V for 9112.

Offset: Voltage offset, from –5 V to 5 V

Zero Ref: Data value corresponding to offset voltage

Filter: Off, 1 MHz, 3 MHz, 10 MHz, 30 MHz or 100 MHz Filter settings are entered by pressing the + and – keys, which move the filter value through the filters available in the AFG. Entering [0] will turn the filter off directly. Filters are available in 8–bit AFG's only.

Output: Connects and disconnects output(s).

Invert: Inverts waveform data if on

Load Compensation: (not available for 8–bit AFG's) Output voltage is calculated into user's load if on, into 50 Ω if off.

Just channel 1 on 8-Bit AFG

Sum Mode: Channel 2 is summed into Channel 1 in the LeCroy AFG and Channel 2 output is off.

Ext Sum: An external signal is summed into Channel 1 of the AFG.

Clock Settings

Period: LeCroy AFG clock period. For 8-bit AFGs, 5.00 nsec/pt to 10.0 sec/pt in single mode; 10 nsec/pt to 20 sec/pt in dual mode. 20 nsec per point minimum for 9112.

Rate: The inverse of the clock period. For 8-bit AFGs, 200 Mpt/sec to 0.1 pt/sec in single mode; 100 Mpts/sec to 0.05 pt/sec in dual mode. 50 MHz maximum for 9112.

Source: Clock source internal or external

Level: Voltage threshold level if external clock source is used. (-2.5 to 2.5 V)

Slope: Slope of external clock source, if used (positive or negative).

Reference: Reference clock, internal or external

Trigger Settings

Mode: Trigger mode: Burst (with count 1 to 65535), Continuous, Gate, Recurrent (with count 1 to 65535), or Single

Arm Source: Auto or Bus

Source bus: On or off

Source external: On or off

Source manual: On or off

Level: Voltage threshold level of external trigger source (-2.5 to 2.5 V)

Slope: Slope of external trigger source (positive or negative)

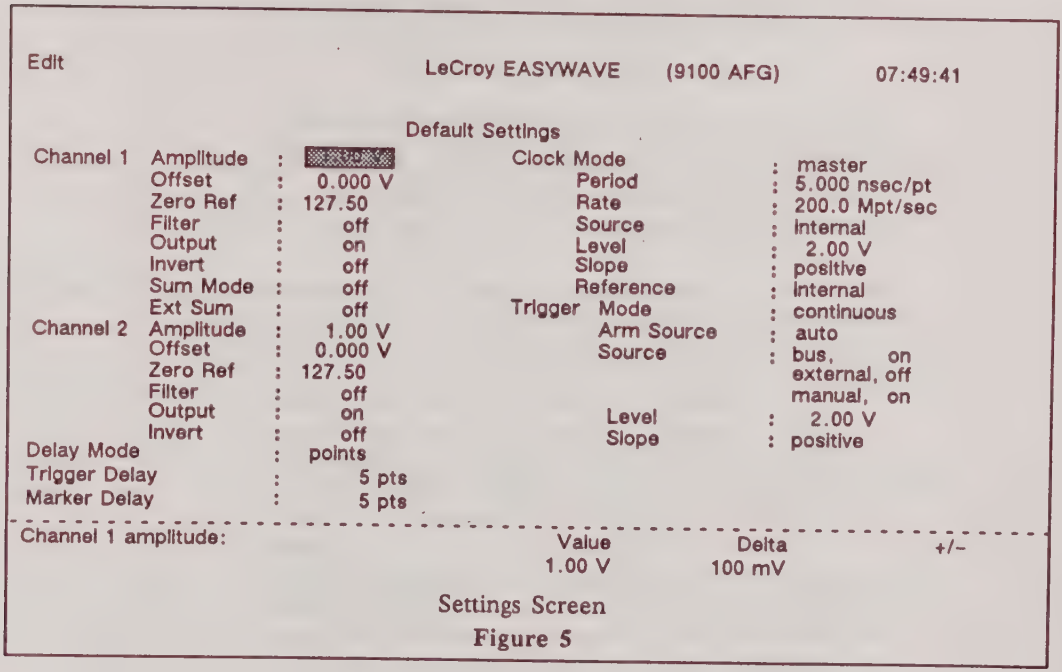
Delay Mode: Points or Time

Trigger Delay – 4 points to 1000000 points, can be entered as time, 16 point minimum for recurrent trigger mode (for 9112: 2 to 500,000 points, 8 point minimum in recurrent trigger mode).

Marker Delay: 4 points to 1000000 points, can be entered as time, 16 point minimum for recurrent trigger mode (for 9112: 2 to 500,000 points, 8 point minimum in recurrent trigger mode).

For dual mode delay limits are 2 points to 500000 points, with an 8 point minimum if the trigger mode is Recurrent. (For 9112: delay limits in dual mode are half of the above numbers.)

Figure 5 shows a settings edit display with default listings for all 8-bit AFG values. For 12-bit AFG's the setting screen will not contain Filter, Sum Mode or Ext Sum, but will have on/off toggles for load compensation and the digital word outputs in each channel. The contents of these settings affect the absolute voltage, amplitude, and time readout of the wave displays in the Edit mode.



Settings Screen

Figure 5

Change any or all settings to reflect desired voltage and time parameters as required. The cursor keys may be used to select the settings parameter to be changed. Once selected, follow the instructions at the bottom of the screen. Sometimes, the instructions will say only:

where pressing [+] or [−] will increment or decrement the Value by the Delta presently displayed. If a different delta is

desired, press [D], which brings up a submenu asking for the new Delta value.

A new parameter value may be set directly without using the Delta. To do so, just enter the desired value or press [V], which brings up another submenu asking for the new value. Proceed as prompted.

NOTE: When a parameter can be entered with a negative value, a prompt at the bottom of the screen will say:

Use "V" to enter a negative value

To enter a negative value for such parameters, press [V] and when prompted, type in [–] and then the desired number. To enter a positive value for the same parameter, however, the number can be typed in with or without pressing [V] and the positive value of that number will be entered.

SEQUENCE EDIT

Sequence files are used to cause the AFG to step through a pre-programmed series of actions. Any valid GPIB control command to the particular AFG (except NEXT) may be used in a Sequence file. Additionally, there is a WAIT command which may be used in the Sequence file.

Sequence files may be used to accomplish such tasks as causing several waveforms to automatically be loaded and linked together. A sequence file may also be used to initiate a pre-programmed series of amplitude and/or clock changes.

WAIT statements may be added to cause the Sequence file to wait until a NEXT command is received either over the bus or from the hand held control panel, if in local mode.

NOTE: WAIT statements may be added here in the Sequence Editing mode. NEXT commands are implemented in EASYWAVE by the Operate mode. Sections 9 and 10 will provide more information on how to implement NEXT commands with EASYWAVE.

Selecting seQuence edit brings up a display that shows the current sequence file (if any), followed by a highlighted line:

End;
----- End Of Sequence -----

if the file is ended on that page. Otherwise, the file continues to additional pages until it is completed.

At the bottom of the screen are the five selections available in the Sequence edit menu:

Sequence edit:	Clear all lines	Edit	Insert	Delete	Line 2

Clear all lines (C): This option erases all lines of the current sequence.

Edit (E): This selection is enabled only if a sequence file exists. An edit line will appear at the bottom of the screen. The desired program line may be typed in and edited. Pressing [Ctrl + ←] will move the edit cursor to the beginning of a line, while [Ctrl + →] will move it to the end of the line. To enter the new line into the program, press the [Enter] key. The new line will replace the highlighted line.

To edit an existing program line, use the cursor keys to highlight the desired line. Use the [PgUp], [PgDn], [Home], and [End] key to access lines on other pages.

Next, select Edit and the highlighted line will appear at the bottom of the screen. It may then be edited. When the [Enter] key is pressed, the edited version of the line will replace the original version.

Insert (I): First select the line above which the new line is to be inserted. Type [I] to begin insertion. A blank edit line appears at the bottom of the screen. The new line may be typed in and when the [Enter] key is pressed, the new line will be inserted. [Esc] can be pressed to bring back the Sequence edit menu. If the sequence editor is initially empty then only the Insert operation is enabled.

Delete (D): First move the highlight to the line to be deleted. When this selection is made, the highlighted line will be deleted.

Line(L): Allows selection of a particular line.

NOTES: 1. Using the File transfer mode, an edited sequence file (.SEQ) may be saved on disk or sent to the AFG.

2. See Section 10 for examples of sequence editing, addition of WAIT statements, and sequence creation.

3. If Sequence files are created for one AFG type, some commands may be invalid for another type. For example, SUM,OFF is not a valid command for Model 9112 AFG. To avoid this kind of problem, put the settings in a Settings

file and reference that file in the Sequence file, e.g., SETUP A.SET;. EASYWAVE will send only the appropriate settings to the AFG.

WAVE EDIT

This selection is made to create and edit waveforms. When the [W] key is pressed from the system menu, the wave edit menu will appear:

Wave edit:	Mode wave	cLear all wave	Array	Block actions	Constant	Equation	Simple elements	sWap channels

NOTE: With the exception of "sWap channels," the wave edit menu selections will create and edit waveforms on Channel 1 only. The "sWap channels" selection is used to switch the contents of Channel 1 with those of Channel 2.

The eight selections in the wave edit menu are described as follows.

Mode

Toggles wave edit mode between Wave (analog output representation) and Logic (digital word output representation).

Clear All Wave

If the waveform in Channel 1 of *EASYWAVE* memory has no points, the words "clear all wave" will be in parentheses and none of the letters in those words will be capitalized, indicating that this item is not selectable.

When some points of a wave are in *EASYWAVE* memory, however, the parentheses will not appear with this selection, and the first word of this selection will appear as "cLear." Pressing [L] will then cause the screen to display a prompt that says:

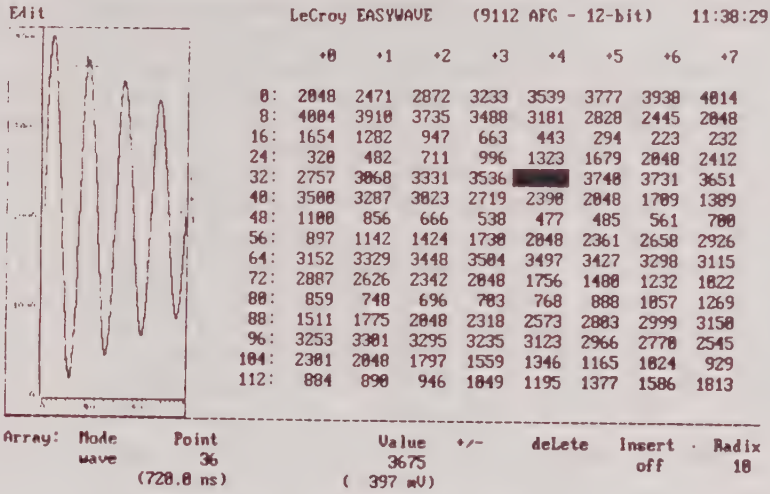
Clear entire wave? (Y/N) [N]:

Pressing [N] (or any key other than Y) will leave the wave alone, while pressing [Y] will clear the wave. Either way, the wave edit menu will reappear.

Array Editing

Array editing allows change of the wave by keying in the value for any point, and permits inserting and deleting of points. See the ARRAY.HLP help screen.

This selection allows each individual point in a waveform to be accessed and modified, if desired. The display, Figure 6, shows a 120 point page of the current waveform for a 12-bit AFG.



Array Waveform and Table

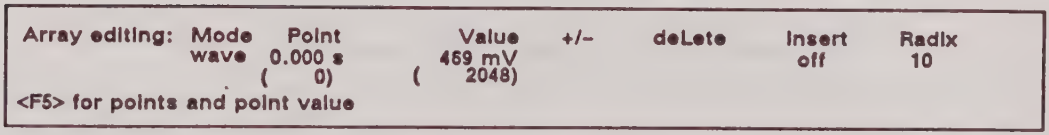
Figure 6

On the left is a portion of the wave display, and on the right is a table of array values. A highlighted cursor may be moved through the table and the wave to select values which are to be edited. To enter or modify a value, simply move the cursor to the desired location and type the value desired, then press [Enter] or an arrow key [←],[→],[↓],[↑].

NOTE: As the highlighted cursor moves through the array, a "crosshair" cursor moves along the wave display.

To access other pages of the array use the [PgUp] and [PgDn] keys on the keyboard. The [Home] and [End] keys can be used to move the cursor to the beginning and end of a wave.

Notice the menu at the bottom of the screen:



NOTE: If the waveform in EASYWAVE memory has no points, "0" will be displayed beneath Point, which will be

displayed in parentheses, and --- will be shown beneath Value. Otherwise, Point and Value will have values assigned as described in the following paragraphs:

Point (P): Represents the horizontal location, in points (or seconds), of the cursor, which may have a range from 0 to one past the last wave point in *EASYWAVE* memory. When a waveform is being worked on, the horizontal cursor location is also shown in units of time. Pressing [P] enables entry of a time point that will move the cursor to that time.

The displayed time is derived from the point number times the clock rate setting. Time units depend upon clock setting, and could be nsec, µsec, msec, or sec.

Value (V): Pressing [V] allows the value of a point to be changed or inserted. Output voltage relates to channel amplitude, Zref, offset, and array value according to the equation:

Vout = (((value – Zref)/MaxData)*ch. amp) + offset

where

MaxData = the maximum value for the AFG data: 255 for 8–bit AFGs, 4095 or 65535 for other AFGs. If a 16–bit AFG has been chosen in Configure Menu, the MaxData value is 65535.

Vout = output voltage
value = array value
ch. amp = full scale channel amplitude

+/–: Upon pressing [+] or [–] the value of a point may be incremented or decremented by one count.

deLete (L): If it is desired to delete a value from the array and have the array collapse to fill the void, move the cursor to the point to be deleted and press [L].

Insert (I): This selection toggles whether an entered value replaces the value at the point of cursor, or inserts a new value at the cursor, in which case the point previously at the cursor (and all subsequent points) will be shifted to one point later.

Radix (R): Pressing [R] allows Array values to be entered and displayed in either decimal or hexadecimal form.

In volts and seconds mode, via <F5>, radix 16 allows entry in binary.

Block Editing

The Block actions selection provides the ability to make block manipulations on the data array. Using a block buffer

that can contain only one waveform or waveform section at any one time, sections of a waveform can be copied to other sections, moved to other sections, deleted, moved vertically, and scaled. Also, sections of a waveform can be saved and recalled from disk. For examples of block editing, see Section 10.

When Block actions is selected by pressing [B] from the Wave edit menu, another menu is displayed:

```
Block:  Mode wave   From disk   To disk   Put in buffer   Delete   Insert from buffer   Vertical move wave   Scale wave
(Insert)
Buffer has 600 points
```

If no waveform is entered into *EASYWAVE*, most of the above menu items will be in parentheses until there is waveform data in *EASYWAVE*. The block action elements are described as follows:

Mode (M)
Toggles edit mode bertween wave and logic.

From disk (F)
This selection provides for recall of a previously saved waveform from disk to *EASYWAVE* memory and to the Block buffer. Pressing the [F] key when the above menu is shown will cause display of the following menu:

```
Insert from disk:  (start )  (duration)  (      to)   Filename   (Ok)
 (to buf)          (0      )
                   (0.000 s)
```

Notice that as shown, the elements in this menu are in parentheses except for "Filename." This means that "Filename" is the only item that can be accessed at this time.

NOTES:

1. *If any waveform is in memory when this menu is entered, "Start" as well as "Filename" will be accessible, as described below.*
2. *When inserting a block from disk, the entire file is accessed as it is stored on disk. Accordingly, the end (to) point of the block is not selectable here, but the end point is shown for the information of the user.*
3. *If no waveforms are on file, a prompt will so indicate by saying that no file is in the disk directory, in which case*

no waveform blocks can be inserted from the disk. If files are on the disk, however, one can be called for by name entry or by using the cursor and enter keys.

4. *Vertical dashed lines called block markers will appear on your PC screen to identify the starting and ending points of specified blocks. If the wave display is expanded the end marker will be at the right edge of the "To" point to define the duration more clearly.*

To access the "Insert from disk" menu, press the [F] key for a waveform file listing and a prompt to enter the name of the waveform stored on disk. After a waveform is specified, select Ok by pressing [O] to get the file from the disk and display the waveform on your PC screen.

Then, press [F] once more to access the "from disk" menu. Notice that the "start" item is no longer in parentheses.

Press [S] to enter the point in time at which the inserted block will start. The screen will say:

```
Starting point (0 to XXXX) [YYY]:

Press C to get from cursor, E for one point past end of wave
```

where XXXX is one point past the end point of the waveform and YYY the current start point (possibly zero). You can now enter any point between zero and XXXX, or use the cursor controls to position the cursor to the desired starting point and press [C], or press [E] for the starting point to be one point past the end of the wave.

To disk (T): Pressing [T] on the block edit menu produces a submenu similar to the "from disk" menu described above. This selection provides for saving a specified section of the waveform to disk and to the temporary storage buffer.

The "put block" to disk menu allows user specification of the start and range (or end point) of the block to be saved. Once the start of the block is defined, the end point must then be defined by pressing [N] (to enter the number of points in the block) or [T] (to enter the last point in the block). Either step will cause display of a prompt allowing an appropriate entry.

NOTE: For any block, it is necessary to specify starting point, plus either "duratioN" (horizontal length of block) or "To" (end point of block). When "duratioN" is changed, "To" is automatically updated, and vice versa.

Put in buffer (P): This capability allows a section of the waveform array to be put into the temporary buffer without storing that section on disk. After pressing [P] to get the "Put block in buffer" submenu, position the cursor at the starting location of the desired section of waveform. The submenu on screen will be:

Put block in buffer: (to buf)	Mode	Start	durationN	To	Ok
	wave	0.000 s (0)	10.00 us (1000)	10.00 us (999)	

each of which can be dealt with as described above.

NOTE: The buffer will be overwritten by all commands except Insert.

Delete (D): This option will delete the specified section of the waveform from the data array and put that section in the buffer.

Values for "Start" and either "To" or "durationN" values must be selected in the delete mode, and then the [O] key (for Ok) should be pressed to achieve the desired deletion. The Delete operation can be undone if immediately followed by Insert.

Insert from buffer (I): This selection allows the section of waveform presently in the block buffer to be inserted into the waveform at a specified point. More than one repetition of the inserted section can be specified. The default number of repetitions is one. As is the case with other block moves, when [O] (for Ok) is pressed, the section will be inserted into the data array.

Vertical move (V): Provides for the relocation of a specified section of the waveform in a vertical direction. The vertical move submenu appears as follows:

Vertical move: (to buf)	Start	durationN	To	Value	Direction	Ok
	0 (0.000 s)	600 (3.000 us)	599 (3.000 us)	0 (0.000 V)	up	

where:

Start (S), durationN (N), and To (T): Provide the menu means for defining the start and stop points of the section to be vertically moved.

Value (V): Allows direct specification of the vertical amount by which the indicated range is to be repositioned. The di-

rection of the vertical move can then be specified by pressing [D] so that the Direction toggles from up to down and back again as required.

After the vertical move selections are made, press the [O] (for Ok) key to move the section. The vertical move can be undone by setting value to 0 and pressing [O].

Scale (S): Provides for rescaling all or any portion of the waveform. When "Scale" is selected, it brings up the following menu:

Scale:	Mode	tYpe	Start	duratIoN	To	fIXed	Factor	Ok
(to buf)	wave	vert'l	0	600	599	128.00	1.00	
			(0.000 s)	(3.000 us)	(3.000 us)	(1.96 mV)		

where:

Mode (M): Toggles wave edit mode between wave and logic.

tYpe (Y): To select vertical (vert'l), horizontal repeated (horiz repeat) or horizontal interpolated (horiz interp) scaling.

Start (S): Provides for selecting the start point for the rescaling.

duratioN (N): Enter the number of points of the waveform to be rescaled. Duration is calculated if "To" is selected.

To (T): Enter the ending point of the section to be rescaled. To is calculated if "duratioN" is selected.

fiXed (X): Determines the amplitude value around which vertical scaling is to occur. Press [X] then enter a number from 0 to 255 for an 8-bit AFG, 0 to 4095 for a 12-bit unit, or 0 to 65535 for a 16-bit device.

Factor (F): Determines how expansion or reduction will occur on the specified section. Specifically, vertical scaling is performed according to the equation:

New amplitude = ((old amplitude – fixed)*factor) + fixed

Ok (O): This selection starts the scaling of the displayed waveform as specified. In other words, no scaling occurs until the [O] key is pressed.

NOTE: When horizontal scaling is specified, a "Buffer" element appears in the scale submenu instead of "fiXed." Horizontal scaling is always performed, however, so that

Buffer x Factor = duratioN

Editing With A Constant

This selection provides the capability to construct part of the waveform at a given level (as in DC level). Press the [C] key and a menu will appear that will allow you to enter not only the constant value but also the horizontal point limits over which that constant will be utilized. This menu is:

Constant:	Mode	Start	duratioN	To	Insert	Constant	Ok
	wave	0.000s	10.00 us	10.00 us	off	498 mV	
		(0)	(1000)	(999)		(32768)	

<F5> for points and point value

Mode (M): Toggles wave edit mode between wave and logic.

To specify the time limits applicable to the constant, **Start (S)**, **duration (N)**, and **To (T)** allow entry of the time at which the constant begins, the time span entered for the constant, and the last point in time to be set to the constant.

Insert (I): toggles from off to on and back again by pressing the I key. When the insert is toggled "off" and [O] is pressed, the specified constant will overwrite and supersede the current waveform (if any) between "Start" and "To." If [O] is pressed when the constant insert is toggled "on," the specified constant will be inserted into the current waveform between "Start" and "To." Instead of being replaced however, the waveform portion originally at any time higher than "Start" will be displaced to the right on the display.

Pressing the [C] key allows entry of a constant value (0 to 255, 4095, or 65535, depending on the AFG type).

NOTES: 1. The entered constant will not be implemented until the [O] key is pressed.

2. As is typical with EASYWAVE displays, voltage and time values are calculated on the basis of the current setting. The [F5] key will permit selection of points or absolute units.

Equation Editing

This selection provides the capability of entering an equation to create a waveform or portion of a waveform. When the

Wave Edit menu is displayed and [E] is pressed, the following submenu is displayed at the bottom of the screen:

```
Eqn: (   start) duratIoN      To       Low      High     scAle Insert  Equat'n  Ok
     (       0)      600     599         0       255        on    off
     ( 0.000 s) (600.0 us) (600.0 us) ( -500 mV) (  500 mV)
SIN(2*PI*T/30)*EXP(-T/100)
```

where:

Start (S), duration (N),and To (T): should be used just as described for previous selections. They define the portion of the waveform which is to be created by the Equation.

Low (L): Sets the lower limit of the amplitude values for calculation of the equation if scAle is on.

High (H): Sets the upper limit of the amplitude values for calculation of the equation if scAle is on.

scAle (A): Determines whether *EASYWAVE* should scale the values resulting from the equation to the low and high amplitude limits. Scale is either on or off.

Insert (I): Toggles from off to on and back again by pressing the I key. When the insert is toggled "off" and [O] is pressed, the waveform corresponding to the specified equation will overwrite the current waveform (if any) between "Start" and "To."

If [O] is pressed when the insert is toggled "on," the waveform corresponding to the specified equation will be inserted into the current waveform between "Start" and "To." Instead of being replaced, the waveform portion originally at any time higher than "Start" will be displaced to the right on the display.

Equat'n (E): Provides for entering the desired equation. When [E] is pressed, the result is a display identifying the name of the current equation file, a listing of any equations previously entered in that file, and the equation edit menu at the bottom of the screen. The [↑], [↓] cursor keys can be used to highlight any equation in the current file. Your choices at this point are:

cLear all lines (L): Permits you to delete all waveform equations in *EASYWAVE* memory.

Select (S): Causes *EASYWAVE* to select the highlighted equation and to return to the previous menu

Edit (E): Allows entry of a new equation or modification of an existing equation. To enter a new equation, for example,

position the cursor to a free line and press the [E] key. Type the equation and press the [Enter] key. To execute that equation, press the [S] key for select.

Delete (D): Removes a highlighted equation from memory.

Current (C): Brings the currently selected equation (if any) to the edit line.

New file (N): Accesses a directory of equation files, each of which may contain as many as sixteen equations. A new equation file may be established at any time by typing [N] from the equation edit menu, entering a name for the new file, and then entering at least one equation in that file by typing [E] to edit and enter that equation.

NOTE: A new equation file will not be saved to disk unless at least one equation is entered in that file.

Equation entry/editing symbols include:

Parameters S for time in seconds
T for time (in points)
PI for 3.1415926...
NOISE for random noise

Special variables C for waveform in channel 1 of EASYWAVE
D for waveform in channel 2 of EASYWAVE
Rn for value of equation on Line n of current equation table

Operators: + - * / ( ) and ^ (for power)

Functions: abs cos exp log ln pulse sin sqrt step tan

Examples:
```
sin(2*pi*T/30)*exp(-T/100)
S*(sin(2*pi* S/40)
(sin(2 *pi*T/40)/T)
log(abs(sin(2*pi* T/60)))
(cos(2*pi*T/80)/(T^3)
```

NOTES 1: Time can be entered in points or seconds, which are related by the current clock setting. Specifically, the time in seconds is equal to the time in points multiplied by the current clock period.

2. Step and pulse are discussed with examples in Appendix E.

3. Use semi-colon (;) for comment after equation or on a separate line.

In addition, you can operate on waveforms in *EASYWAVE* memory and also on equations listed in *EASYWAVE* memory. In this regard, C is the current waveform in Channel 1 of *EASYWAVE*, D is the current waveform in Channel 2 of *EASYWAVE*, and Rn (R1, R2, R3,...Rn) are the equation line numbers corresponding to the waveform equations list in *EASYWAVE* memory.

Accordingly, entering C*2 as an equation means to multiply by 2 the current Channel 1 waveform. Similarly, 3*R1 triples the equation on line 1, and R6+D is the equation on line 6 plus the current waveform in Channel 2 of *EASYWAVE*.

NOTE: 1. The maximum number of points in a wave is 65536 (64K) for an 8-bit AFG, and 32768 (32K) for other AFGs.

2. Although the Channel 2 waveform can be used as an equation entry parameter, keep in mind that the resultant equation will appear on Channel 1 until the "sWap channels" command is given from the wave edit menu.

3. After an equation is selected and the equation menu displayed with "Ok" on the far right, the [O] key must be pressed to calculate the waveform points from the equation and to display that waveform on your PC screen.

Editing With Simple Elements

Pressing [S] when the wave edit menu is displayed provides the capability to create portions of a waveform by using predefined shapes or simple elements. In this regard, when the simple elements options is selected, a menu of 9 such elements is displayed:

```
Simple elements:   Sine      Dc/step    Exponential
                   sQuare    Triangle   daMped sine
                   Ramp      Gaussian   Freq sweep

Save settings to preserve volts and seconds.
```

Each of the 9 options lead to further menu options as described below:

Sine (S): This selection provides for setting up the parameters for the sine wave simple element; when [S] is chosen, a submenu appears as follows:

Sine:	Frequency	Period	Cycles	Start phase	More
	50.00 kHz	20	1	0.00 deg	
		(20.00 us) (	20 pts)		

Frequency: Press [F] and enter the desired frequency using the first letter of the modifier, if any: (m for millihertz, K or k for kilohertz, or M for megahertz). If Period is selected, Frequency is a calculated value.

Period: Press [P] and enter the desired period of the sine wave, using the first letter of the unit modifier, if any: (n for nanoseconds, u for microseconds, m for milliseconds). If Frequency is selected, Period is a calculated value.

Cycles: Provides for specifying the number of cycles of the sine wave. Press [C] and enter the desired number of cycles.

Start phase: Provides for defining the start phase for the sine wave. Press [S] and enter the desired number of degrees.

More (M): Accesses an additional sine wave menu page with five additional items:

More sine:	Start	Low	High	Insert	Ok
	0	0	255	off	
	(0.000 s)	(-1.00 V)	(1.00 V)		
<F5> for seconds and volts					

where:

Start (S): Sets the start point for the standard element and can be input by a number or from the cursor.

Low (L): Sets the lower limit calculated for the selected element.

High (H): Sets the upper limit calculated for the selected element.

Insert (I): Toggles from off to on and back again. When the insert is toggled "off" and [O] is pressed, the specified standard waveform element will overwrite the current waveform (if any) between "Start" and the end of the simple element segment (determined by entered values for period and number of cycles).

If [O] is pressed when the insert is toggled "on," the specified standard element will be inserted into the current

waveform. Instead of being replaced, the waveform portion originally at any time higher than "Start" will be displaced to the right on the display.

Ok: When all the settings are as desired, press [O] and the sine wave will be created in *EASYWAVE*.

Triangle (T), or Square (Q) wave elements can also be selected, each producing a submenu like that described above for sine wave elements. The only difference is that the start phase for these elements is specified in units of time, rather than in degrees.

Ramp (R) elements result in the same submenu as described for square and triangle waves. An additional command in the Ramp menu, however, enables specifying whether the slope of the ramp is to be positive or negative. Ramp slope is toggled from positive to negative by pressing [L].

Dc/step (D) waveform elements are accessed with a submenu prompting for entry of width per step (W), number of steps (S), number of levels (L), total time (T), and positive or negative slope (toggled by pressing [P]).

Once those parameters are entered, the [M] key must then be pressed to access the second part of the Dc/step menu, which is identical to the second part of the sine element menu as described above, but without the start phase parameter.

NOTE: When using DC/step elements, either S or L can be entered, with EASYWAVE automatically calculating the other according to L = S+1.

*Similarly, width/step, levels, and total time are related by W*L = T. If W and L are specified, T will automatically be calculated by EASYWAVE. When T is changed W will be adjusted automatically.*

Damped sine waves (M) have a menu similar to that described above for sine waves, but with the addition of a prompt for time constant. Damped sine waves are produced here in accordance with the equation:

```
sin((2*pi*t/period) + start phase) * exp (-t/time constant)
```

As with all other simple elements damped sine waves have two parts, the second of which is accessed by pressing [M] for More. That second part is identical to that described for

sine waves earlier and includes the Ok command that must be given to construct the waveform element in *EASYWAVE*.

Exponential waves are produced by pressing [E] from the simple element menu. Another menu will then appear as follows:

Exponential: EXP(T/200)	time Constant 200 (1.000 us)	Total time 1000 (5.000 us)	Sign positive	suBtract no	More

Where Sign toggles from positive to negative by pressing [S], and suBtract toggles from no to yes by pressing [B]. The form of the exponential equation varies with sign and subtract according to the following table:

Sign	Subtract	Form
positive	no	EXP(T/C)
positive	yes	1-EXP(T/C)
negative	no	EXP(-T/C)
negative	yes	1-EXP(-T/C)

If entry is in volts and seconds, the equation has "S" instead of "T" and the constant is in seconds instead of points.

The second part of the exponential element menu is accessed by pressing M for More. That second part is identical to that previously described for the DC/Step function, and includes the Ok command that must be given to construct the waveform element in *EASYWAVE*.

Gaussian waves are generated by pressing [G] when the simple element menu is displayed. The resulting Gaussian menu is quite simple, having only three entry prompts:

Sigma (S) which is the half-width at the inflection point and the standard deviation of the Gaussian.

Total time (T) which allows entry of the total elapsed time after the start of the wave.

More (M) accesses the second menu page for the Gaussian element specification. Again, this is identical to the second page of the DC/Step simple element menu, as described previously.

Frequency Sweep allows a swept sine wave to be created. Such a wave can vary linearly or logarithmically over a user-selected time span between user-selected frequencies. Pressing [F] from the simple elements menu results in appearance of the frequency sweep menu:

Freq sweep:	Freq1	fReq2	Period1	pEriod2	Time	tYpe	More
	200.0 kHz	400.0 kHz	1000	500	1000	lin	
			(5.000 us)	(2.500 us)	(5.000 us)		
<F5> for seconds and volts							

where:

Freq1 (F) and fReq2 (R) are used to specify the initial and final frequency limits, respectively

Period1 (P) and pEriod2 (E) are alternate ways of defining the sweep limits. (Only frequency or period need be input, not both)

Time (T) is the desired sweep time

tYpe (Y) toggles from lin (linear) to log (logarithmic) and back again when [Y] is pressed to indicate the type of sweep to be created.

More (M) accesses the second frequency sweep menu page, which permits specifying the start point for the frequency sweep element, as well as the low and high limits for that element. The second page also contains the OK (O) command that creates in *EASYWAVE* the specified frequency sweep wave segment.

sWap Channels

Pressing [W] when the wave edit menu is displayed will cause the contents of Channel 1 to be interchanged with the contents of Channel 2.

To create a waveform in Channel 2 of *EASYWAVE*, that waveform must first be created in Channel 1 and then moved into Channel 2 by invoking "sWap channels." After swapping, Channel 1 will have whichever waveform had previously been in Channel 2. If Channel 2 originally had no waveform, Channel 1 will have no waveform after the swap.

To edit a waveform that is in Channel 2, "sWap channels" must also be invoked, since editing can occur only on waveforms in Channel 1 of *EASYWAVE*.

NOTE: For a two-channel AFG, swapping involves exchange of not only waveforms, but of channel settings as well. When waveforms only are intended to be swapped, make the settings identical for both channels,

FILE TRANSFER MODE

This mode handles transfers between PC disk, LeCroy *EASYWAVE* memory, a LeCroy AFG, and a LeCroy oscilloscope. Pressing the [F] key when the system menu is displayed will result in display of the file transfer menu:

File transfer:	Disk to ew	dIsk to afg and ew	Ew to disk	eW to afg	Afg to disk and ew	aFg to ew	More

where:

Disk to ew (D): from PC disk to *EASYWAVE* memory

dIsk to afg and ew (I): from PC disk to AFG file system and *EASYWAVE*

Ew to disk (E): from *EASYWAVE* memory to PC disk

eW to afg (W): from *EASYWAVE* memory to AFG file system

Afg to disk and ew (A): from AFG file system to PC disk and *EASYWAVE* memory

aFg to ew (F): from AFG file system to *EASYWAVE* memory

More (M): accesses additional file transfer menu options. If the [M] key is pressed when the file transfer menu is being shown, another file transfer submenu appears as follows:

*Note 1: In transferring files from "dIsk to afg", wild cards can be used to transfer one or more files of a given type from the disk to the AFG (Settings, Wave, Dual wave, or seQuence). The rules for representing wild cards are the same as those for the PC DOS, e.g.,, * or x* or ??xx or A:*.*

2. *The asterisk wild card can be used from "Afg to disk" to transfer all files of a given type.*
3. *The asterisk wild card can also be used in "dElete afg" (see below) to delete all AFG files of a given type.*

More files:	Delete disk	dIr disk	dElete afg	dIR afg	Get from scope	Merge .WV1,.WV2	Current dIr \EW

where:

Delete disk (D): Delete a file on the PC disk

dIr disk (I): Show files in a directory on the disk

dElete afg (E): Delete a file in the LeCroy AFG file memory

diR afg (R): Show files in the LeCroy AFG file memory

Get from scope (G): Gets wave files with descriptors from the LeCroy Oscilloscope.

Merge (M): Merges .WV1 and .WV2 files (used on previous versions of EASYWAVE into a .WAD file so old files can be used with new EASYWAVE.

Current dir (C): Identifies current directory and allows change

Each file transfer selection defined above will result in a submenu of additional selection options. In implementing these options, the following facts will be of value:

1. LeCroy *EASYWAVE* has three main file types: Wave, Setting and Sequence.
2. Each can be stored on the disk or in the AFG with extensions: .SET for settings files; .SEQ for sequence files; .WAV, for single channel wave files, and .WAD for dual channel wave files.
3. Dual channel wave files can be sent to a single channel AFG but only the channel 1 data will be generated.
4. A settings file contains all settings as shown in the Settings display.
5. A sequence file is a list of AFG commands, and can be used to minimize the typing necessary for the AFG to generate waveforms.
6. Wave files reside in Channel 1 or Channel 2 of *EASYWAVE*.
7. Wave files can be read from disk or AFG into EASYWAVE memory for Channel 1 and swapped into Channel 2. Similarly, a wave file in Channel 2 can be swapped into Channel 1 and then stored on disk or in the AFG.
8. The "All" command is used to transfer all kinds of files associated with a single-channel waveform with the selected filename, e.g., SINE100.SET, SINE100.SEQ, and SINE100.WAV.
9. The "aLL" command does similar transfer but for dual-channel, e.g., SINE100.SET, SINE100.SEQ, and SINE100.WAD.

10. For transfers from AFG to disk, any DOS mask can be used, e.g., A*.*.
11. For transfers from AFG to disk, any one or all files of a given type can be transferred.
12. A file on disk with extension .DAT is a wave file in ASCII. Its format is ASCII numbers (0 to 255 for 8-bit AFGs, 0 to 4095 for 12-bit AFGs and 0 to 65535 for 16-bit AFGs) separated by spaces or commas or other non-numeric separators. EASYWAVE will read in a .DAT file and convert it to a normal .WAV file.
13. Many of the file transfer menu choices result in file listings that tabulate specific types of files. Each such listing features a highlighted cursor. Position the cursor to the file which is to be selected and press the [Enter] key. An alternate method is to type in the name of the file and the press the [Enter] key.

Commands in the file transfer submenus include the following:

All: This selection brings up a display listing all three kinds of files (Settings, Sequence and Waveforms) stored on the disk. Users have the option of all single channel (Ch1) files (selected by pressing [A] for All single) or all dual channel files (L for aLL dual).

Calling up a file from all single or all dual will automatically call up all files (Setting, Sequence, and Waveform) with the same root name as that of the requested file.

Settings (S): This selection brings up a listing of only the Settings files stored on disk.

seQuence (Q): Brings up a listing of only the Sequence files stored on the disk.

Wave (W): Brings up a listing of the single waveforms stored on the disk.

Dual (D): Lists dual waveforms stored on the disk

Masked (M): For disk directory and delete this selection provides for viewing all of the files in the current directory whether they are *EASYWAVE* related or not. For example: entering *.* on the "mask" line will cause all files in the current directory to be displayed. Typing *.exe will cause only the executable files in the current directory to be displayed. A*.WAV, for example, will bring up WAV files starting with A. This feature can be used to show the files on a floppy disk by entering [A:].

Current dir (C): To change to another directory within which you may have stored Waveform, Setting, Sequence, or Equation files, type [C]. The designation for the current directory will be displayed in the disk directory menu beneath the Current dir wording.

Typing [C] from the disk directory menu will produce a

Change current directory:
\EW

message, where EW is the designation for the current directory. All *EASYWAVE* directory names use the format: \ followed without spaces by the directory name. The default directory is \EW.

If you have files stored in other directories, use the [backspace] key to clear the name of the current directory, and then type the name of any other directory you wish to access.

Get from Scope (G): This menu item provides the capability to acquire waveforms from a LeCroy oscilloscope into EASYWAVE memory. When this selection is made, the following menu is displayed:

Get from Scope:	Type 9100 AFG	tYpe 9400 Scope	Scope channel 1	Easywave channel 1	Ok

where:

Type: Selects the LeCroy AFG type as on the Configuration menu.

tYpe: Selects the LeCroy Oscilloscope Model number. EASYWAVE will try to address other models if there is no response from the selected model. If "No Scope" is selected EASYWAVE will try to address the LeCroy Model 9400 first.

Scope channel: Represents which channel of the Scope is to be acquired. Select by pressing the [S] key to toggle the entry from 1 to 2 and back again.

Easywave channel: Represents the *EASYWAVE* channel in which the Scope waveform will be stored. Toggle from 1 to 2 and back again by pressing [E].

Once the menu is set as desired, press [O] for Ok and the waveform will be acquired from the scope. See Section 10 for an example of using the "Get from Scope" capability.

NOTE: Make sure the Scope GPIB address set under the CONFIGURE menu matches the address on the back of the Scope. If the address on the back of the Scope is changed, the Scope must be turned off and on again so the new setting will be read.

OPERATE MODE

Operate mode allows control of the LeCroy AFG. It sends commands to the AFG and receives settings, status and other responses from the AFG. If there is a problem communicating with the AFG the GPIBPROB.HLP screen will be displayed indicating possible sources of the problem. The Operate mode menu has six selections:

Function generator (F): for sine, square, triangle, ramp and DC.

Pulse generator (P): for pulse waves

Arbitrary function generator (A): for arbitrary (user-designed or captured) single waves (and dual waves for a dual-channel AFG).

Selftest afg (S): Causes the AFG to go into its Selftest mode (takes about 70 seconds).

Calibrate afg (C): Calibrates the AFG (takes about 7 seconds).

Identify afg (I): Display Model and firmware revision level.

ARBITRARY FUNCTION GENERATOR OPERATION

When A is selected from the Operate menu, the ARBITRARY help screen and the current settings will be listed on your PC display. A list of options will be printed across the bottom of the screen pertaining to the operation mode of the AFG. Those options are:

Operate arbitrary:	Load wave	(link) (wave)	Settings change	leaRn setup	Afg action

Load wave (L): This will give you a directory of all the files that are currently loaded in the file memory of the AFG. One of these files must be loaded into the fast memory of the AFG.

You can load any of the files that are already in the file memory of the AFG either by typing in the name of the file or by moving the backlighting to the file that you want to load and pressing the return key. Extension ".WAV" is for single waves and extension ".WAD" is for dual waves.

To complete loading, you must tell the AFG how many repetitions you want. Default is one.

When a wave is loaded, the high speed memory of the AFG is cleared, and the selected wave is moved into high-speed

memory. The number of repetitions of the selected wave defaults to one, but can be as many as 4095.

linK wave (K): Files are again displayed as above. You can link any of the same type files that are already in the file memory of the AFG either by typing in the name of the file or by moving the backlighting to the file that you want to link and pressing return.

After selecting the file that you want to link, you must tell the AFG how many repetitions you want, Default is one, but a maximum of 4095 repetitions are possible.

As many as 682 wave files may be linked; one which has been loaded, followed by 681 that have been linked in sequence.

The same wave files may be linked several times within a given waveform. For example: You could load wave file A, link wave file B with four repetitions, and link wave file C once, and then link B again, this time with three repetitions.

Settings change (S): This selection permits changing the current AFG settings.

NOTE: Settings changed in the Operate mode are automatically changed in the AFG and do not have to be transferred to the AFG by means of the File transfer mode.

LeaRn setup (R): EASYWAVE will display a directory listing of all existing settings files in the AFG file memory. A prompt will also appear, requesting a filename. The current settings may be saved by selecting and overwriting an existing filename, or by typing in an appropriate new name, and pressing the [Enter] key. Once the settings file is created the directory listing will be updated showing any changes which have just been made.

The last item in the Operate arbitrary menu is Afg action. Press [A] and the six choices in the Afg action menu will appear:

Setup afg from file (S): Allows selection and installation of any settings file in the AFG file memory.

run seQuence file (Q): Allows selection and execution of any sequence file resident in the AFG file memory, until the END or WAIT command is encountered. The run seQuence menu includes Next seq cmd and Abort run seq to control sequence execution.

Go (G): Generate the wave in the AFG high-speed memory, subject to selected trigger mode requirements.

Abort wave (A): Abort wave generation.

aRm trigger (R): Arm the trigger.

Trigger (T): Fire the trigger

NOTE: Arming and firing the trigger is necessary only for single and burst trigger modes. Trigger mode requirements are described in the AFG operating manual.

PULSE GENERATOR OPERATION

When the Operate menu is displayed and the [P] key is pressed, the pulse generator sub-menu appears on screen as follows:

Pulse:	Period 200.0 usec	Width 200.0 nsec	Delay 100.0 nsec	Optimize width	Settings chg leaRn setup Afg action

where selecting P, W, and D enables specification of the pulse period, width, and delay.

Repeatedly pressing the [O] key toggles optimization from width to period to delay. This optimizing recognizes that specifying period, width, and delay may present conflicting commands; toggling with the [O] key allows you to specify which of the three parameters you require the most precise control over in generation of the pulse.

Settings change, leaRn setup, and Afg action are as discussed above for Operate Arbitrary.

STANDARD FUNCTION GENERATOR OPERATION

Pressing [F] when the operate menu is displayed will result in display of the function menu as shown below:

Operate Function:	Sine	sQuare	Triangle	Ramp	Dc

Choosing either Sine (S), sQuare (Q), Triangle (T), or Ramp (R) will produce a menu similar to the following menu (the Dc selection will be described below):

Sine:	Mode single	Frequency 1.000 MHz	Period 200 (1.000 us)	sTart 0.000 deg	(2nd rel phase) N/A	Settings chg leaRn setup Afg action

where:

Mode: Toggles from single to dual channel by pressing [M]

Frequency: Sets frequency for any function (F key)

Period: Sets period (use instead of setting frequency) by first pressing [P]

sTart: Specifies Channel 1 starting phase in degrees for sine, or in time for any of the others.

2nd rel phase: Press [2] to set relative phase of 2nd channel (dual mode only)

Settings change, leaRn setup, and Afg action are as discussed above for Operate Arbitrary.

For DC voltage generation, press [D] when in the Operate function menu shown above. A DC menu will appear, where the choices are Mode, Settings change, leaRn setup, and Afg action, each of which is used as described above.

For the Model 9112, DC voltages for the 2 channels can be set directly from this menu. For 8-bit AFG's, the output voltage is set by adjusting the channel offset voltage under setting change.

TYPICAL EASYWAVE OPERATIONS

This section describes the use of *EASYWAVE* by means of examples showing how to perform the following basic operations:

- Creating, storing, and executing a single channel waveform.
- Creating and storing a dual channel waveform.
- Creating and storing a linked waveform.
- Editing a waveform
- Storing a waveform captured by a LeCroy Oscilloscope
- Making a SEQUENCE file to automatically execute a command sequence

The description of each operation is presented as an *EASYWAVE* tutorial in an action response format. User actions, shown within square brackets [ ], define inputs that must be typed into the computer. These brackets are not to be typed; only the text between the brackets need be typed.

NOTE: Square brackets may sometimes appear within EASYWAVE menus, where they enclose default values, in these cases they will appear in bold type and do not represent user inputs.

EASYWAVE itself is not generally case-sensitive and there is no need to capitalize letter entries. Exceptions are for unit prefixes such as m for milli, M for Mega, also z for zoom-out and Z for zoom-in commands.

Computer screen responses are shown in the form of menus, which will be shown in Bold lettering.

CONFIGURING EASYWAVE

The system menu appears on your PC screen automatically upon *EASYWAVE* startup. To configure *EASYWAVE* to your needs, type [C] when the system menu is on screen and the configure help screen and menu will be displayed as shown in Figure 7.

Configure LeCroy EASYWAVE 07:54:05

Help File CONFIG.HLP

Gpib	the GPIB address for the PC to use, default = 0.
Name	the name of the GPIB board, default GPIB0, other GPIB1.
Afg	the GPIB address of the LeCroy AFG, default = 1.
Type	Selects AFG Model. If 9101 AFG, no channel 2 settings needed. If No AFG, allow menus in Operate mode without any AFG connected. Also selects 12 or 16 bit data format for 9112 AFG.
Scope	the GPIB address of the LeCroy Scope, default = 4.
tYpe	9400, 9420, 9450 or No Scope. No Scope allows Get from Scope menu without any Scope.
dMa	default is as set in GPIB.COM using IBCONF. Can be turned off in EASYWAVE if PC2A board or PC clone needs it off. If (dma) then DMA is turned off in GPIB.COM and cannot be turned on in EASYWAVE. Returns to GPIB.COM setting when leave EASYWAVE.
Join dots	If yes, join data-point dots together with lines.
Help	If on, get automatic help screens first time in any menu.
Colors	If color display, select colors.

These changes are saved on disk so permanent until further change by user

Configure mode:	Gpib	Name	Afg	Type	Scope	tYpe	dMa	Join dots	Help	Colors
	0	GPIB0	1	9100 AFG	4	No Scope	on	on	on	

Configure Menu and Help Screen

Figure 7

Keeping in mind the capital letter keying of *EASYWAVE* menus, configuring is accomplished by means of the following steps:

1. Set the GPIB addresses and GPIB board name accordingly. Typing [A], for example, produces the prompt:

Configure AFG address (0 to 15) [1] : _

which indicates that you can enter any numeric address from 0 to 15, with the default address being 1.

2. Set dMa (direct memory access) and color as required.
3. Make certain that **on** appears beneath both **Join dots** and **Help**. If **off** appears beneath **Join dots**, type [J]. If **off** appears beneath **Help**, type [H].
4. Change Type to 9100 AFG to agree with examples in this tutorial, or select your AFG model and expect some variations in screens and limits.

5. Return to the System menu by pressing [F4] or [Esc].

NOTES:

1. *Once Configure mode settings are entered as described above, those settings are automatically saved on your PC disk and do not have to be re-entered unless you wish to change them.*
2. *The following examples are assumed to be implemented from startup. When Help in the Configure mode is set to on, context-sensitive help screens will appear automatically when EASYWAVE is in any menu for the first time after that particular startup.*

CREATING, STORING AND EXECUTING A SINGLE CHANNEL WAVEFORM

This example will construct a 10-cycle sine burst. The order of operations is as follows:

a. Create a Settings File that summarizes the desired frequency and amplitude ranges for the desired waveform.

b. Use the Constant and Simple elements functions of the Wave edit menu to create the desired waveforms.

c. Save the completed waveform to disk and to the AFG using File Transfer menu operations.

d. Make use of the *EASYWAVE* Operate mode to output the waveform from the AFG.

Creating a Settings File

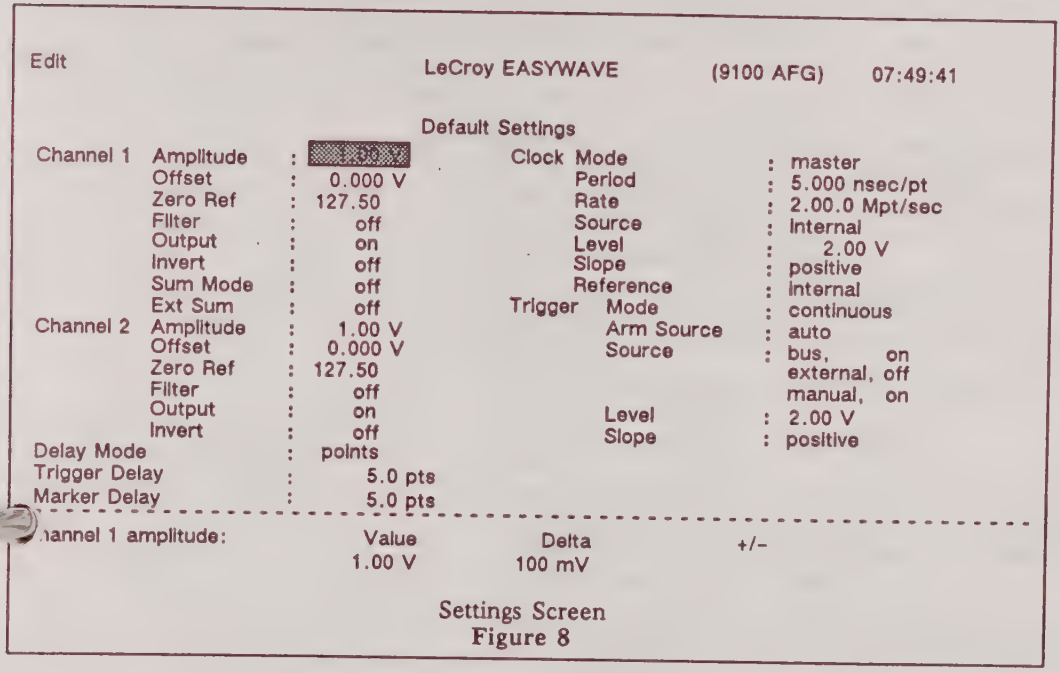
The first operation required in waveform generation is to select the desired waveform parameters and to set up the AFG using a Settings file. We will use a 2 V peak to peak output voltage level. The sampling clock rate will be set to 1 µsec/pt.

Steps in this activity are:

1. Get into the System menu, which appears automatically upon *EASYWAVE* startup.
2. Select the **Edit** mode by typing [E]. The Edit mode menu gives a choice of Settings edit, seQuence edit, or Wave edit. Select **Settings edit** by typing [S], and a listing of default settings will appear on screen, Figure 8, with Channel 1 Amplitude backlit.

NOTE: The settings screen shown is for the Lecroy Model 9100 AFG. Other models may have slightly different settings, e.g., for Lecroy Model 9101 AFG, channel 2 settings

are suppressed; for LeCroy Model 9112 AFG, Load compensation is shown and filter, sume mode and ext sum are not shown.



Settings Screen
Figure 8

3. Type [V] to change the Channel 1 amplitude value. The bottom of the screen will now change to say:

Channel 1 amplitude value (5 mV to 10 V) [1.00 V] : _

The amplitude range may vary with the particular AFG.

4. Type [2] and then [Enter]. The settings listing will now show an amplitude of 2.00. At the same time, the Channel 1 amplitude value/delta menu will reappear at the bottom of the screen, with 2.00 V displayed as the current value.

NOTE: The actual instantaneous output voltage of the AFG will depend upon amplitude setting, the offset voltage setting, the zero reference (Z ref) setting, and the actual value

of the waveform at any given point. The following equation represents the relationship between these variables:

$$V_{output} = V_{amplitude} * ((DATA - Z_{ref})/ Max\ Data) + V_{offset}$$

where:

MaxData = the maximum value for the AFG data: 255 for 8-bit AFGs, 4095 or 65535 for other AFGs. If a 16-bit AFG has been chosen in Configure Menu, the MaxData value is 65535.

V_{output} = actual output voltage

$V_{amplitude}$ = full scale amplitude setting (p-p)

DATA = waveform amplitude (0 - Max Data) in point value form

Z_{ref} = zero reference setting, DATA value for Voutput = Voffset

V_{offset} = output offset voltage setting

The EASYWAVE display cursor can read each amplitude value of a waveform directly in volts. The [F5] function key will alternate the cursor amplitude readout between point values or volts.

5. Use the cursor keys to highlight the Clock Period on the settings list. Notice that the menu at the bottom of the screen will say:

Clock period:	Value	Delta	+/-
	5.000 nsec/pt	10.00 nsec/pt	

Type [1] to start to change the clock period value to 1 µsec. The menu is then replaced by:

```
Clock period: (5.0 nsec/pt to 5.0 sec/pt) [5.000 nsec/pt ]:1_
```

NOTE: In this example we did not type V for value. If a number is entered without first selecting V, for Value, or D, for Delta, Value is the assumed target. To enter a negative value you must press V first.

Type [u] to set the units to microseconds and then [Enter]. Note that the settings listing now shows a clock period of 1.000 µsec/pt, while the clock period menu reappears, showing a current value of 1.000 µsec/pt.

NOTES: 1. Settings units (e.g., seconds, volts, Hertz) do not have to be entered.

2. Clock period and rate ranges vary with AFG model number.

6. Verify that the trigger mode is set to continuous. If not, use the cursor keys to backlight the trigger mode and type [C].
7. Press [F5] to change the units display to point and point value. Screen will retun the message "<F5> for seconds and volts."

Creating A Single Channel Arbitrary Waveform Using the EASYWAVE Simple Elements Library

1. Return to the Edit Menu by pressing [F2]. Select Wave edit by typing [W]. The Wave edit menu and help screen will be displayed, Figure 9.

```
Edit                          LeCroy EASYWAVE          (9100 AFG)     07:49:41
                              Help File WAVEEDIT.HLP
With LeCroy EASYWAVE, waves can be changed in several ways:
Mode            Toggles between wave (points) and logic (bits).
Clear           Clears all points of the wave after checking, or clears all bits in one bit stream
                after bit number entry.
Array           Change the wave by point or by bit value, and by inserting and
                deleting one point or bit at a time, see ARRAY.HLP and ARYLOGIC.HLP.
Block actions   Operate on many points or bits, see BLOCK.HLP.
Constant        Set many points or bits to a constant.
Equation        Set many points of the wave via equation, see EQUATION.HLP.
Simple Element  Use simple functions to calculate points, see ELEMENTS.HLP.
sWap channels   Interchange the waves in EASYWAVE channels 1 and 2
<F5> switches entry and display (points vs seconds, point value vs volts)
Wave edit:  Mode wave   (clear) ( all ) ( wave)   Array   Block actions   Constant   Equation   Simple elements   ( swap ) (channels)
<F5> for seconds and volts
```

Wave Edit Menu and Help Screen

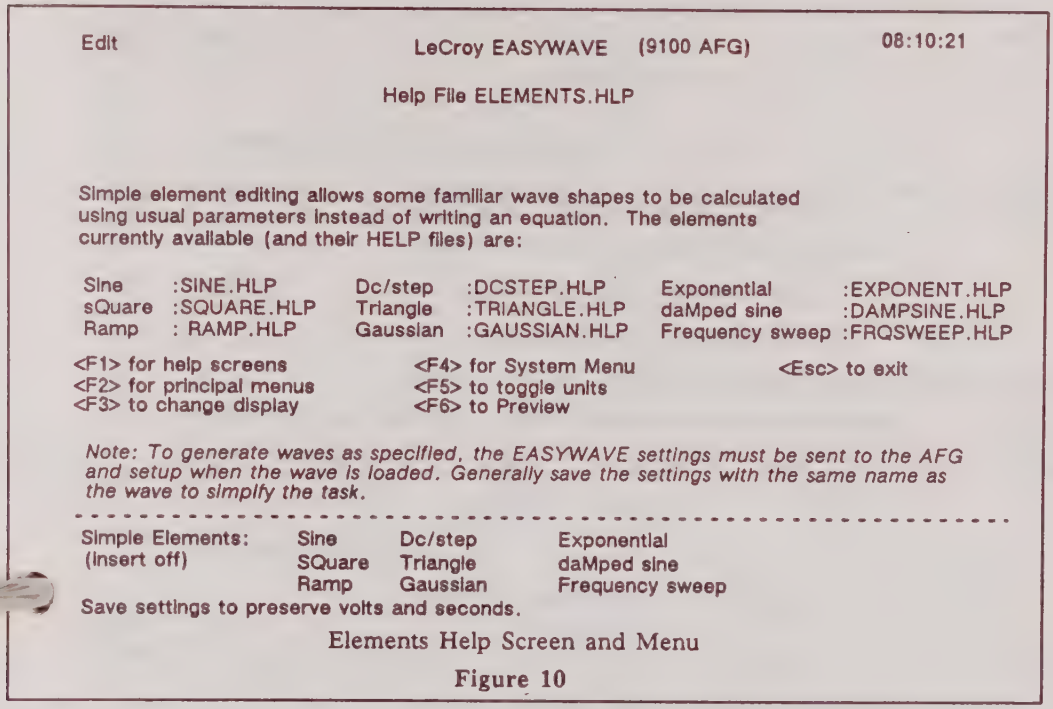
Figure 9

2. Choose **Constant** by typing [C]. The Wave edit menu will be replaced by the Constant menu as follows:

```
Constant:   Mode wave   (  start)  duratioN      To     Insert   Constant      Ok
                        (      0)       600      599      off        128
                        ( 0.000 s) (600.0 us) (600.0 us)           ( 3.92 mV)
<F5> for seconds and volts
```

3. Press [O] to stipulate that the constant waveform segment is **OK** as entered and to command *EASYWAVE* to create that waveform as specified. The waveform will then be displayed over the wave constant menu.

4. Press [Esc] to access the Wave edit menu and choose **Simple elements** by typing [S]. The Elements help screen and menu will then appear as shown in Figure 10.


Edit
LeCroy EASYWAVE (9100 AFG)
08:10:21
Help File ELEMENTS.HLP
Simple element editing allows some familiar wave shapes to be calculated using usual parameters instead of writing an equation. The elements currently available (and their HELP files) are:
Sine :SINE.HLP
sQuare :SQUARE.HLP
Ramp : RAMP.HLP
Dc/step :DCSTEP.HLP
Triangle :TRIANGLE.HLP
Gaussian :GAUSSIAN.HLP
Exponential :EXPONENT.HLP
daMped sine :DAMPSINE.HLP
Frequency sweep :FRQSWEEP.HLP
<F1> for help screens
<F2> for principal menus
<F3> to change display
<F4> for System Menu
<F5> to toggle units
<F6> to Preview
<Esc> to exit
Note: To generate waves as specified, the EASYWAVE settings must be sent to the AFG and setup when the wave is loaded. Generally save the settings with the same name as the wave to simplify the task.
Simple Elements: (Insert off)
Sine
SQuare
Ramp
Dc/step
Triangle
Gaussian
Exponential
daMped sine
Frequency sweep
Save settings to preserve volts and seconds.

Elements Help Screen and Menu

Figure 10

5. Type [S] and the SINE.HLP display will appear above a default sine menu, Figure 11.

```
Edit                          LeCroy EASYWAVE      (9100 AFG)      08:10:21
                              Help File SINE.HLP

The simple element Sine allows selection of:

Frequency        frequency of the sine, based on current values of the Clock rate
                 (or frequency) in the EASYWAVE settings file
Period           period of the sine (the inverse of the frequency)
Cycles           the number of cycles of the sine wave
Start phase      the starting phase of the sine wave in degrees
More             more parameters, common to all simple elements, see ELEMMORE.HLP
<F5> switches entry and display (points vs seconds, point value vs volts)
-------------------------------------------------------------------------------
Sine:      Frequency      Period        Cycles      Start phase          More
           1.000 kHz        1000             1          0.00 dg
                         (1.000 ms)    ( 1000 pts)
<F5> for seconds and volts
```

Sine Menu Below Sine Help Screen
Figure 11

6. Type [F] to enter the sine wave frequency and the sine menu will be replaced by:

```
Sine frequency  (15.25 Hz to 125.0 kHz) [1.000 kHz]: _
Remember: m for milli and M for Mega
For different input range, change clock rate or period in Settings
```

Now type [50k] and [Enter]. The sine menu will again appear, with the current frequency set to 50.00 kHz. The period will be 20 µsec (20 points).

7. Type [C] to access the sine cycles menu:

```
Sine cycles:  (1 to 3276) [1]: _
```

Type [10] and then [Enter]. The sine menu will again appear, this time with 10 shown as the current value of cycles.

8. Type [M] and the sine menu will be replaced by the "More sine" menu as follows:

```
More sine:        Start        Low         High          Insert      Ok
                    0           0          255            off
                (0.000 s)  (-1.00  V)   (1.00  V)
use <F5> for seconds and volts
```

9. Hit <F5> if values in seconds and volts are not in parentheses. If <F5> is hit accidentally, just hit it again.

10. Type [S] to set the starting point and the "More sine" menu will be replaced by:

```
Starting point (0 to 600)  [0]:_
C to get from cursor, E for point past end of wave
```

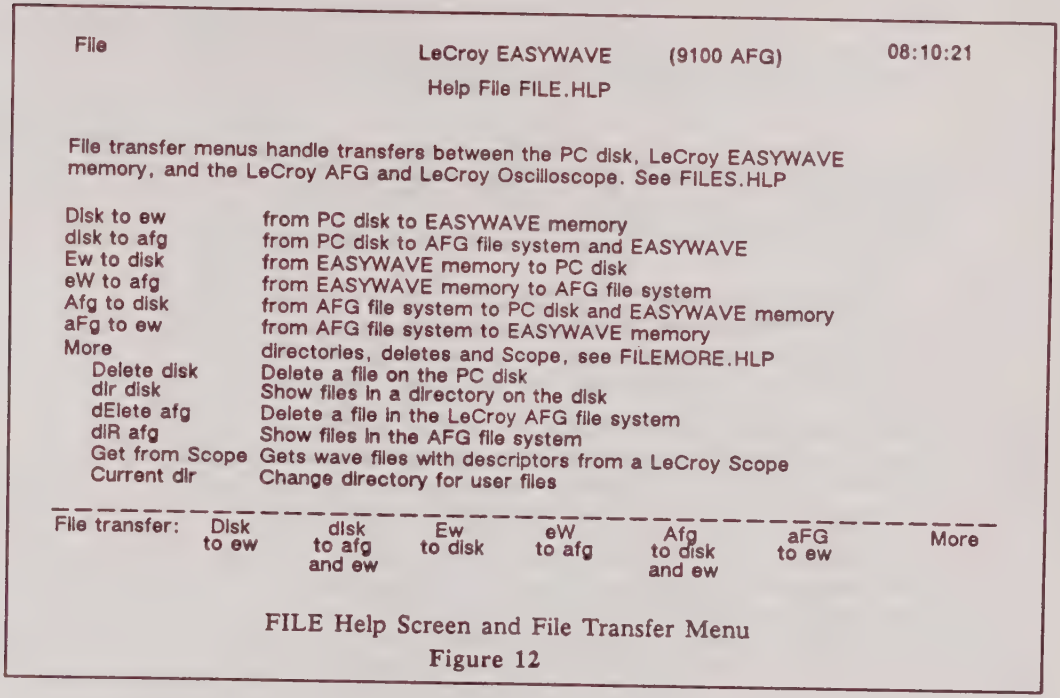
Type [200] and [Enter] to establish a starting point of 200 for this portion of the waveform. The "More sine" menu will then reappear, with a start at 200.

11. Since all the necessary parameters for the sine wave have been entered, type [O] to indicate that it is OK to create that wave as specified. The sine wave will then be displayed in the middle of a DC waveform.

    The same waveform could have been created using a variety of techniques; for example, three segments could have been created, a constant, the sine wave, and another constant. The method described in the preceding ten steps requires fewer operations, but the user has complete flexibility in selecting which "style" to use.

Storing A Single Channel Arbitrary Waveform

1. To save the waveform to disk, press [F4] to get back to the **System** menu. Access the **File transfer** menu by typing [F]. The FILE help screen will now appear above the **File transfer** menu as shown in Figure 12. *Note that the operating mode field in the upper left hand corner of the display screen has changed to File indicating that EASYWAVE is now in the file transfer mode.*


File
LeCroy EASYWAVE (9100 AFG) 08:10:21
Help File FILE.HLP
File transfer menus handle transfers between the PC disk, LeCroy EASYWAVE memory, and the LeCroy AFG and LeCroy Oscilloscope. See FILES.HLP
Disk to ew from PC disk to EASYWAVE memory
disk to afg from PC disk to AFG file system and EASYWAVE
Ew to disk from EASYWAVE memory to PC disk
eW to afg from EASYWAVE memory to AFG file system
Afg to disk from AFG file system to PC disk and EASYWAVE memory
aFg to ew from AFG file system to EASYWAVE memory
More directories, deletes and Scope, see FILEMORE.HLP
Delete disk Delete a file on the PC disk
dir disk Show files in a directory on the disk
dElete afg Delete a file in the LeCroy AFG file system
diR afg Show files in the AFG file system
Get from Scope Gets wave files with descriptors from a LeCroy Scope
Current dir Change directory for user files
File transfer:
Disk to ew
disk to afg and ew
Ew to disk
eW to afg
Afg to disk and ew
aFG to ew
More

FILE Help Screen and File Transfer Menu

Figure 12

2. Save data to disk by typing [E] to access the *EASYWAVE* to disk menu:

3. Type [A] to select **All single** to save both the settings and the waveform. It is not necessary to save both settings and the waveform at the same time. Waveforms may be stored without an associated settings file.

   At the prompt:

   All files from EW to disk – name [AM50.WAV]: _

   The default file name "AM50.WAV" will be system specific and may be different.

   Type [BURST] and [Enter]. BURST.SET and BURST.WAV will be added to the listing of files in the current disk directory (reference Section 9 for a discussion on accessing and changing the current directory).

At the same time, the File transfer menu shown in Figure 12 will again appear at the bottom of the screen.

Executing A Single Channel Waveform

The preceding paragraphs have shown how to create a single channel waveform, how to create settings for that waveform, and how to store both the settings and the waveform on PC disk.

Before the Model 9100 Arbitrary Function Generator can execute that waveform, however, the *EASYWAVE* File Transfer mode must be used to move the waveform and its associated settings to the RAM memory of the Model 9100.

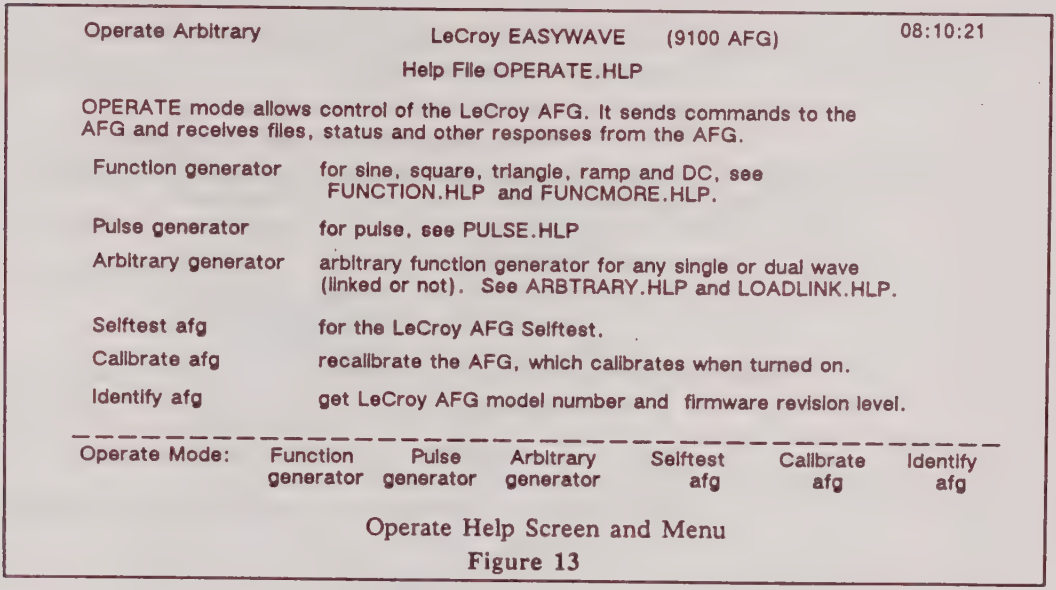
The Model 9100 can execute only those waveforms loaded into its high speed memory. The *EASYWAVE* Operate mode may be used to **Load** the waveform from the file memory of the AFG and then to give the **GO** command to execute.

1. To send the sine burst waveform and its associated settings to the AFG, type [Esc] until the file transfer menu again appears at the bottom of the screen. Notice that the second choice in that menu is **dIsk to afg**. Type [I] to access that choice and the menu at the bottom of the screen will change to:

Disk to AFG:	All	aLL	Settings	seQuence	Wave	Dual
and ew	single	dual				wave

2. Now type [A] to bring up the settings, sequence and waveform files in the current directory. Use the cursor keys to highlight BURST.SET and type [Enter] to transfer that setting to the AFG. The main File transfer menu will then reappear beneath a directory of AFG files. A notation at the bottom of the screen will confirm that BURST.SET and BURST.WAV have been transferred to the AFG.

3. To load and run the wave, either *EASYWAVE* or the handheld control panel may be used. To use *EASYWAVE* type [F4] to return to the system menu and [O] to go into the Operate mode. The Operate help screen and menu will appear on your PC screen as shown in Figure 13.


Operate Arbitrary
LeCroy EASYWAVE (9100 AFG)
08:10:21
Help File OPERATE.HLP
OPERATE mode allows control of the LeCroy AFG. It sends commands to the AFG and receives files, status and other responses from the AFG.
Function generator
for sine, square, triangle, ramp and DC, see FUNCTION.HLP and FUNCMORE.HLP.
Pulse generator
for pulse, see PULSE.HLP
Arbitrary generator
arbitrary function generator for any single or dual wave (linked or not). See ARBTRARY.HLP and LOADLINK.HLP.
Selftest afg
for the LeCroy AFG Selftest.
Calibrate afg
recalibrate the AFG, which calibrates when turned on.
Identify afg
get LeCroy AFG model number and firmware revision level.
Operate Mode:
Function generator
Pulse generator
Arbitrary generator
Selftest afg
Calibrate afg
Identify afg

Operate Help Screen and Menu

Figure 13

5. Type [A] to access the Arbitrary mode. The Arbitrary help screen and Arbitrary menu will then be displayed, Figure 14. Note that EASYWAVE will also report AFG memory availability.

```
Operate Arbitrary          LeCroy EASYWAVE    (9100 AFG)          08:10:21
                           Help File ARBTRARY.HLP

Menus in OPERATE Mode, Arbitrary function generator

  Load wave        clear high-speed memory and move wave from AFG file memory (non-vola-
                   tile RAM disk) to high-speed memory, see LOADLINK.HLP.
  Link wave        move another wave of same type (single or dual) to high-speed
                   memory (if not already there) and link it in.
  Settings change  change any LeCroy AFG setting:
                   for channel settings see CHANSET.HLP
                   for clock settings see CLOCKSET.HLP
                   for trigger and delay settings see TRIGSET.HLP
  leaRn setup      from active AFG settings to AFG file memory, specify name
  Afg action       request AFG action, see ACTION.HLP
-------------------------------------------------------------------------------
Operate arbitrary:  Load wave   (link) (wave)   Settings change   leaRn setup   Afg action
682 lines left in control memroy, 65536 bytes left in high-speed memory
```

Arbitrary Help Screen and Menu

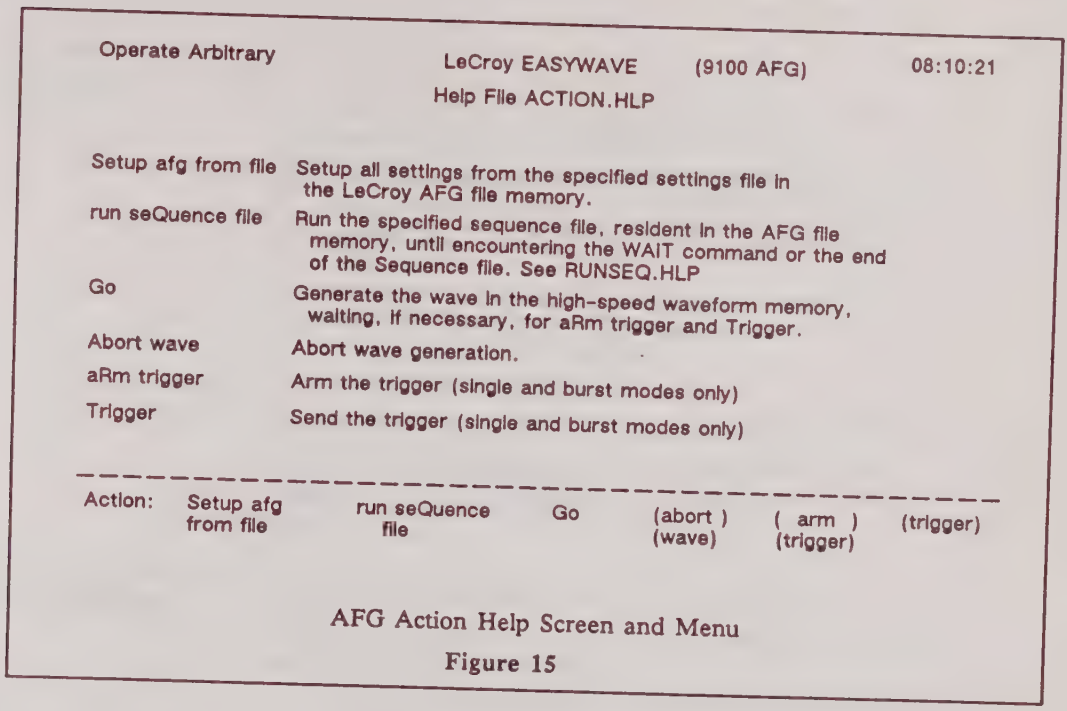
Figure 14

6. Type [L] to load the sine burst waveform into the high speed memory of the AFG. The screen will show a listing of waveform files loaded into the current directory. Use the cursor keys to highlight BURST.WAV and type [Enter]. A prompt at the bottom of the screen will then say:

```
Load BURST.WAV with repetition count ( 1 to 4095) [1]:_
```

7. Type [Enter] to signify that you will accept the default value of one (the waveform will be executed once and not repeated). The Operate arbitrary menu will again appear on screen, above a statement confirming that BURST WAV has been loaded. EASYWAVE will also ask at this time if it should setup the AFG from BURST.SET. Respond [Y], and EASYWAVE will initiate the setup file, inform you when setup is complete and display a directory of the AFG's control memory.

8. Type [A] and the Afg action menu and help screen will appear, Figure 15:


Operate Arbitrary
LeCroy EASYWAVE (9100 AFG) 08:10:21
Help File ACTION.HLP
Setup afg from file
Setup all settings from the specified settings file in the LeCroy AFG file memory.
run seQuence file
Run the specified sequence file, resident in the AFG file memory, until encountering the WAIT command or the end of the Sequence file. See RUNSEQ.HLP
Go
Generate the wave in the high-speed waveform memory, waiting, if necessary, for aRm trigger and Trigger.
Abort wave
Abort wave generation.
aRm trigger
Arm the trigger (single and burst modes only)
Trigger
Send the trigger (single and burst modes only)
Action:
Setup afg from file
run seQuence file
Go
(abort) (wave)
(arm) (trigger)
(trigger)

AFG Action Help Screen and Menu

Figure 15

9. Type [G] to give Go command for the AFG to execute the waveform as specified. The **waveform active** and **Chan 1** LEDs on the AFG will light up and the waveform you created will appear at the AFG's channel 1 output. On the screen, the go option now appears in parentheses, and the parentheses that were previously around the Abort wave selection have been removed.

10. Type [A] to abort the waveform output. The AFG's **waveform active** and **Chan 1** LEDs will go out, output activity on channel 1 will cease, and the EASYWAVE display will change to the Active Settings listing. The line at the lower right of this list will read:

    LeCroy AFG status: stopped

11. Type [G] again to re-start the waveform. The LED's will light again, the waveform will again be running on the AFG's channel 1 ouput, and the last line of the Setting listing will change to:

    LeCroy AFG status: active

CREATING AND STORING A DUAL CHANNEL WAVEFORM

To create and store a dual channel waveform, one must proceed through four basic phases as follows:

a. Edit the settings file to get the amplitude, offset, and other parameters desired for each channel. Set the common settings parameters such as the clock and trigger mode settings.

b. Create the waveform in Channel 1 then swap it into Channel 2 (the swap operation moves the channel–related settings with the waveforms).

c. Create the second waveform.

d. Transfer the dual waveform to disk and/or the AFG.

Note: for single–channel AFG's dual waveforms can be stored in the AFG file memory, but only channel 1 will be generated.

Creation Of The Waveform Intended For Channel 2

Waveforms are created and edited in Channel 1.

In this regard, there are several ways in which a waveform can be created in Channel 1:

- It can be newly specified in accordance with the wave edit menu.
- It can be transferred to Channel 1 from PC disk storage or file system in the AFG.
- It can be captured by the Oscilloscope and transferred to Channel 1 of *EASYWAVE*.

Assume for purposes of this tutorial that the waveform intended for Channel 2 is the sine burst created and stored as described in Section 10.

1. To access that sine burst, type [F] from the system menu to access the File transfer menu. The sine burst is stored on disk, so type [D] from the file transfer menu. The Disk to *EASYWAVE* menu will then appear as follows:

Disk to EW:	All single	aLL dual	Settings	seQuence	Wave	Dual wave

2. Type [A] to transfer all files with the same root filename. Notice that BURST.SET and BURST.WAV are

listed. Use the cursor keys to highlight either of those files and type [Enter]. The sine burst waveform will be displayed above the File transfer menu. A message at the bottom of the screen will say that BURST.WAV and .SET have been obtained from disk.

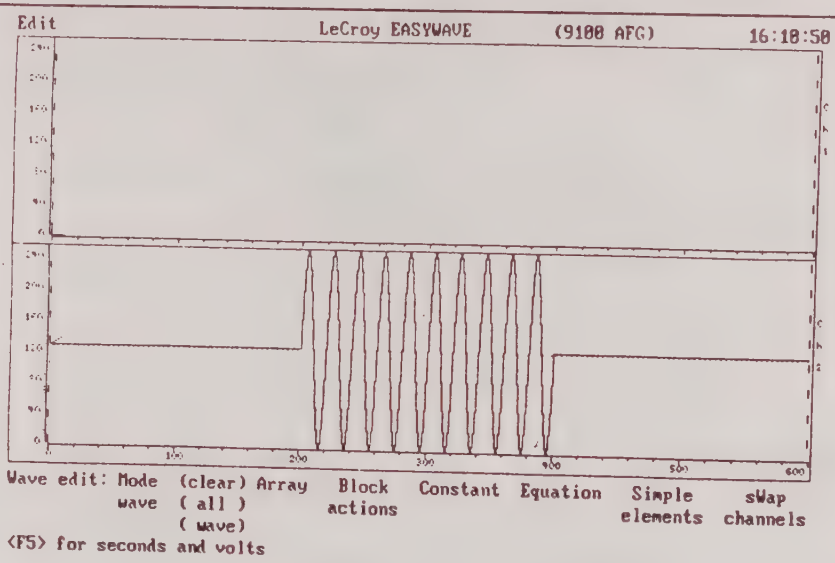
NOTE: When you are showing all files in memory, accessing a filename will transfer all files with that name. Accordingly, typing [Enter] with BURST.SET highlighted will also transfer BURS. WAV and would also transfer BURST.SEQ if it existed.

Transferring the Waveform To Channel 2

1. To move a waveform from Channel 1 to Channel 2, one must "swap" the contents of Channel 2 with the contents of Channel 1. In this case, press [Esc] or [F4] to return to the system menu, [E] to go into Edit mode, and [W] for Wave edit. The Wave edit menu will then appear on screen.
2. The last item on the Wave edit menu is **sWap channels**. Type [W] to access that item, which swaps the contents of Channel 2 with the contents of Channel 1. In this instance, Channel 2 was empty and Channel 1 contained the sine burst. As a result, typing [W] to swap channel contents will produce the display shown in Figure 16, where Channel 1 is empty and Channel 2 contains the sine burst.

NOTES

1. *The sWap channels command swaps waveforms AND settings.*
2. *Editing must be performed in Channel 1. If a Channel 2 waveform must be changed, it must first be transferred (via sWap channels) to Channel 1.*



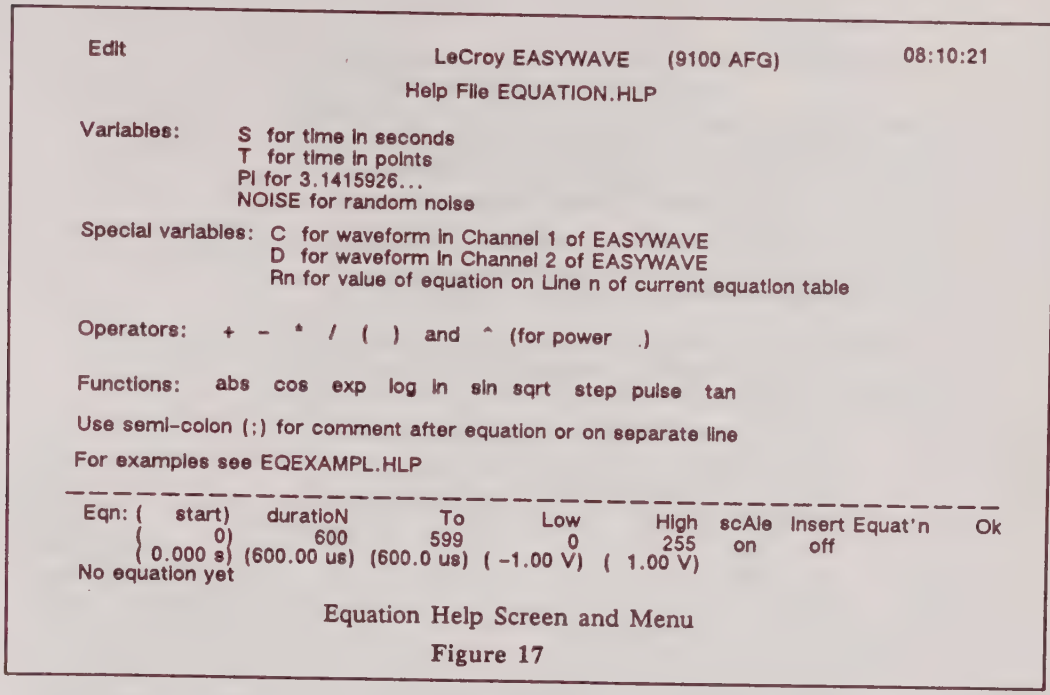
Dual Display with Channel 1 Empty

Figure 16

Creation of the Second Waveform Using Equation Entry Editing

A waveform can be created in Channel 1 in either of the ways listed in Section 10. The following illustrates waveform creation by equation input.

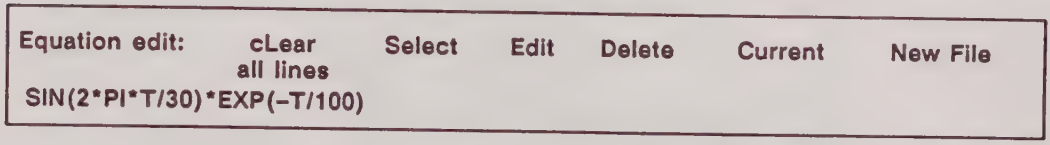
1. The wave edit menu is displayed at the conclusion of the sWap channel step described above. Type [E] and the equation menu will appear as shown in Figure 17.


Edit
LeCroy EASYWAVE (9100 AFG)
08:10:21
Help File EQUATION.HLP
Variables:
S for time in seconds
T for time in points
PI for 3.1415926...
NOISE for random noise
Special variables:
C for waveform in Channel 1 of EASYWAVE
D for waveform in Channel 2 of EASYWAVE
Rn for value of equation on Line n of current equation table
Operators: + - * / ( ) and ^ (for power .)
Functions: abs cos exp log ln sin sqrt step pulse tan
Use semi-colon (;) for comment after equation or on separate line
For examples see EQEXAMPL.HLP
Eqn: (start) durationN To Low High scAle Insert Equat'n Ok
(0) 600 599 0 255 on off
(0.000 s) (600.00 us) (600.0 us) (-1.00 V) (1.00 V)
No equation yet

Equation Help Screen and Menu

Figure 17

2. Type [E] and the screen will change to show a listing of equations already entered into *EASYWAVE* memory. At the bottom of the screen will be the equation edit menu:



NOTE: If no equations have been entered in EASYWAVE memory, cLear all lines, Select, and Delete will be in parentheses and inaccessible.

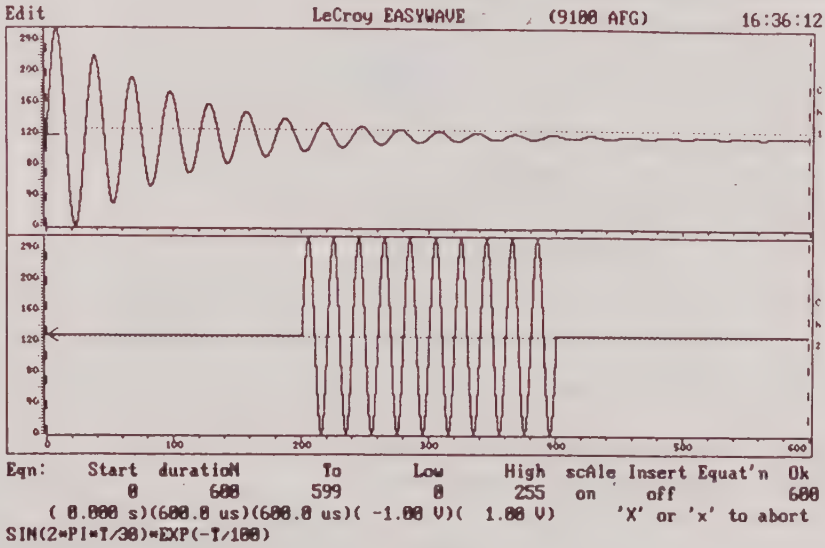
3. A line in the equation listing will be highlighted. If an equation is listed on that line, use the cursor keys to highlight an open line. Once you have highlighted a line on which no equation has been entered, type [E]. The Equation edit menu will disappear.

4. Type [sin(2*PI*T/30)*exp(-T/100)] (do not type the square brackets) and then [Enter]. The entered equa-

tion will then appear in the highlighted line and the Equation edit menu will reappear.

5. Type [S] to Select the entered equation and the dual display first seen in Figure 16 will again be seen, this time with the entered equation shown in the lower left corner of the screen and the equation menu.
6. Type [O] to verify that the equation is Ok as entered, and the waveform created by that equation will appear in the Channel 1 portion of the dual display, Figure 18.

NOTE: When creating a dual waveform, each channel should have the same number of points. Otherwise, EASYWAVE will pad out the shorter waveform. In this example each waveform has 600 points.


Edit
LeCroy EASYWAVE (9100 AFG)
16:36:12
Eqn: Start duratioN To Low High scAle Insert Equat'n Ok
0 600 599 0 255 on off 600
(0.000 s)(600.0 us)(600.0 us)(-1.00 V)(1.00 V) 'X' or 'x' to abort
SIN(2*PI*T/30)*EXP(-T/100)

Dual Display

Figure 18

Storing The Dual Channel Waveform

1. To store the dual waveform shown in Figure 18, type [F4] to access the system menu. Then, type [F] and the File transfer menu will be displayed.

2. Type [E] to access the EW to disk menu:

EW to disk:	All single	aLL dual	Settings	(sequence)	Wave	Dual wave

Now type [S] to access the current directory of setup files, and enter a filename for the setup file used to create the dual wave. Type [DUO] as the file name (*EASYWAVE* will automatically add .SET) and then type [Enter]. The File transfer menu will reappear at the bottom of the screen, a notation beneath that menu will say "DUO.SET from EW to disk" and DUO SET will be added to the list of settings files in the directory.

NOTE: In contrast to our previous example, we have elected to save the settings and the waveform files independently. This is to illustrate the ability to use several settings files in conjunction with one waveform. A typical use of this feature is to output the same waveform while changing its amplitude, offset, or other parameter for tolerance testing.

3. To save the dual waveform created above, you must once again type [E] from the File transfer menu to access the EW to disk menu. Then, type [D] to save the dual wave to disk. A dual wave directory will appear, above a prompt that says:

Save dual wave files to disk – name [filename.WAD]:

4. Type [DUO] as the name of dual waveform, and then type [Enter]. The dual waveform is now saved.

CREATING, STORING AND EXECUTING A LINKED WAVEFORM

The AFG enables as many as 682 stored waveforms to be "linked" together and executed in any user selected sequence. The first waveform in such a chain is moved into the AFG's high speed memory (a waveform cannot be executed unless it is in the high speed memory) by a Load command, while any and all waveforms added to the chain are moved into high speed memory by the Link command.

Up to 681 links can be made (682 files together, including the waveform originally loaded in high speed memory), with as many as 4095 repetitions of each.

In the simple case of linking two waveforms with *EASYWAVE*, four steps are required:

1. Create each waveform separately in *EASYWAVE* memory. For archiving purposes, a wise procedure would be to store each of the waveforms on PC disk.
2. Use the file transfer mode to move the waveforms into the AFG file memory.
3. Use the Operate mode to load the first waveform into the AFG high speed memory.
4. Use the Operate mode to link the second waveform and to issue the Go command to execute both waveforms linked together.

The following example assumes that you have already created and stored a sine burst waveform (BURST.WAV) in the AFG file memory and that *EASYWAVE* Channel 1 contains the damped sinewave function created by equation entry.

1. BURST.WAV is in the AFG file memory and Channel 1 of *EASYWAVE* has the damped sine wave, created by equation. This waveform will be saved as LINK2.WAV.
2. Type [F4] to cause the system menu to appear at the bottom of the PC screen and type [F] to go into the File transfer mode. Press [E] to initiate transfer from *EASYWAVE* to disk. When the **EW to disk** menu then appears at the bottom of your PC screen, type [W] and you will be prompted to:

```
Save wave file to disk - name [filename.WAV]: -
```

Type [LINK2] and [Enter]. The screen will indicate that the LINK2.WAV waveform file has been saved on disk, and the File transfer menu will again appear.

3. Now that the waveform to be linked is stored on disk, the next step is to transfer it to the file memory of the AFG. Again, this is accomplished via the File Transfer menu.

Notice that the second choice in that menu is **dIsk to afg and ew**. Type [I] to access that choice and the menu at the bottom of the screen will change to:

Disk to AFG: and ew	All single	aLL dual	Settings	seQuence	Wave	Dual wave

4. Type [W] to access the single waveform files in the current directory. When the listing of files appears, use the cursor keys to highlight **LINK2.WAV** and type [Enter] to transfer that waveform to the AFG file memory.

5. Type [F4] for the system menu and then type [O] to go into the *EASYWAVE* Operate mode so you can load the waveform. The **Operate** menu will appear at the bottom of your PC screen.

6. Type [A] to access the **Arbitrary** menu. Then, type [L] to load the sine burst waveform into the high speed memory of the AFG. The screen will show a listing of waveform files loaded into the current directory. Use the cursor keys to highlight **BURST.WAV** and type [Enter]. A prompt at the bottom of the screen will then say:

```
Load BURST.WAV with repetition count ( 1 to 4095 ) [1]:_
```

7. Type [Enter] to accept the default value of one (the waveform will be executed once). The **Operate arbitrary** menu will again appear on screen, above a statement confirming that BURST.WAV has been loaded and inquiring if you wish to setup the AFG from BURST.SET. Enter [N] and a directory of the AFG's control memory will appear on screen containing only 1 item, BURST 1W.

8. Type [K] to link another waveform into high speed memory. The screen will show a listing of waveform files in the AFG. Use the cursor keys to highlight **LINK2.WAV** and type [Enter]. A prompt at the bottom of the screen will then say:

```
Link LINK2.WAV with repetition count ( 1 to 4095 ) [1]:_
```

9. Type [2] to signify that you will want this waveform segment to be output twice and then press [Enter]. EASYWAVE will then ask if this segment should be linked with the wait for trigger option. Type [N] (see your AFG Operators Manual for an explanation of this option). The **Operate arbitrary** menu will again appear on screen, above a statement confirming that LINK2.WAV has been linked and the control memory directory will be displayed, as follows:

```
BURST   1W
LINK2   2
```

11. Type [A] and the **Afg action** menu will appear.
12. Type [G] to give the Go command, and the chained waveform segments will be executed in the following order:

```
BURST.WAV once
LINK2.WAV twice
BURST.WAV once
LINK2.WAV twice
etc.
etc.
```

NOTE: By editing and saving on disk, files can be created without the AFG. Later the files can be transferred into the AFG.

BLOCK EDITING OF WAVEFORMS

EASYWAVE provides editing capabilities that allow the user to edit waveforms by manipulating selected segments of a waveform (block editing), or by editing on a point by point basis (Array editing). Each type of editing has specific advantages in certain applications.

Array editing permits fine control of individual data points in a waveform. Array editing is virtually self explanatory; it can be used to add or delete narrow waveform features such as "noise spikes" to a waveform. Array editing is also helpful in repairing errors resulting from incorrectly joining waveform segments.

Block editing is somewhat more complex since it allows several different operations, but it is also the more generally

used editing mode. It permits rapid waveform modification in Channel 1 of the *EASYWAVE* wave edit display. Blocks may be defined, inserted, or deleted using cut and paste techniques similar to those found in word processing programs.

Also in Block editing, waveforms may be stretched or contracted in both the horizontal and vertical axes by means of the scaling function. Additional information on the block edit mode is found in Section 7.

Accessing the Block Edit Mode

A waveform created earlier in this tutorial will be used to demonstrate waveform editing. This 600-point waveform is a damped sine wave defined by the equation:

SIN(2*PI*T/30)*EXP(-T/100)

1. Reconstruct this waveform (0 to 600 points) using the equation editor, or by recalling it from disk where it was stored as LINK2.WAV. The damped sine waveform should be displayed on the screen. Press [F4] to return to the system menu.

NOTE: If the waveform display does not appear on screen, press [F3] and then [1] to cause the display to be shown.

2. From the system menu type [E] for **EDIT**, the edit menu will appear. Type [W] to select Wave edit and cause the **Wave edit** menu to appear on screen.
3. Activate Block editing by typing [B] for **Block actions**. The Block menu will appear as shown:

Block:	Mode wave	From disk	To disk	Put in buffer	Delete	Insert from buffer	Vertical move wave	Scale wave

NOTE: Editing involves defining, modifying, and re-arranging waveform segments. This process normally is done by transferring segments to a memory for temporary storage. EASYWAVE uses either disk storage or a temporary storage buffer.

The buffer, which is the only memory permitting modification of a segment, is the most often used temporary storage area for block actions. The Block menu has provision for both types of storage.

As you enter the Block editing mode, the screen will show the size of the current buffer contents. The maximum size is 32768 for 8-bit AFG's and 16384 for any other AFG.

Copying and Moving a Waveform Segment

1. A waveform segment may be copied by first putting it into the buffer. This is done by typing [P] for the **Put in buffer** selection in the Block menu. This results in a Put Block in buffer menu that is used to define the start, end, or duration (number of points) of the desired waveform segment, as shown below:

```
Put block in buffer:     Start    duratioN       To          Ok
(to buf)                   0         600         599
                      (0.000 s) (600.0 us) (600.0 us)
```

The default values are for the latest waveform manipulation; in this case, the creation of the damped sine wave. Change the start by typing [S]. *EASYWAVE* will prompt the user for the starting point with the following:

```
Starting point (0 to 599) [0] :_
C to get from cursor
```

The starting point may be entered by typing in the desired number, which must be between the limits given within the parentheses, and pressing [Enter]. The default value is shown within the square bracket.

Another alternative is to move the display cursor, using the cursor keys, to the desired starting point and typing [C]. The current cursor location would then be entered as a starting point.

2. Type [100] and press [Enter]. This will select a waveform segment starting at the 100th point. The To value is set by typing [T] and at the prompt

```
Ending point (100 to 65536) [599]:_
C to get from cursor
```

type [199] and [Enter]. The Put block in buffer menu now indicates a start value of 100, the number of points (duration of the block) is 100, and the end point is 199.

3. Type [O] to signify that the indicated block size is Ok and to load that block into the buffer. At the completion of loading the buffer *EASYWAVE* will return to the Block menu and display the message:

```
Put 100 points [100 to 199] in buffer.
```

Two vertical dashed lines, called markers, will appear on the waveform display indicating the limits of the block that has been transferred into the buffer.

4. Type [I] to access the **Insert from buffer** command. The Insert block menu will appear:

```
Insert block:  (mode )      Start    (duration)    (       to)  Repetitions   ok
from buf)      (wave )        100    (     100)    (      199)            1
                          (100.0 us)  (100.0 us)   (200.0 us)
```

Since the size of the waveform segment in the buffer was fixed when we put it into the buffer, we can only select the start point and the number of repetitions.

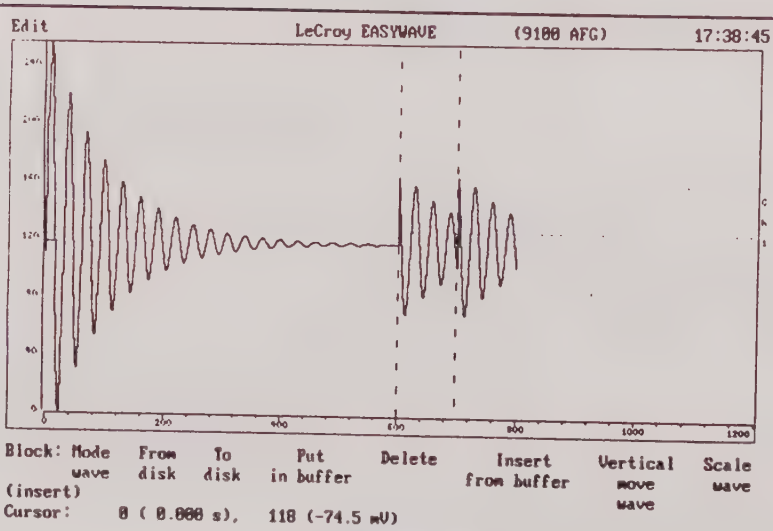
5. Now type [S] to enter the start point at which we will insert the contents of the buffer. Instead of entering the start point numerically, however, type [E] to set the start point at the point following the end of the current waveform, which is 600.

The waveform segment in the buffer may be duplicated multiple times by entering the desired number of repetitions in the Insert block menu. Type [R] to select Repetitions. The following entry prompt will appear:

```
Insert block repetitions:  (1 to 649) [1]: _
```

The default value is 1. The range of repetitions, in this case 1 to 649, is determined by the size of the waveform segment in the buffer. The segment length times the number of repetitions plus the existing wave size cannot exceed 65,536 points for 8-bit AFG's and 32768 points for any other AFG.

6. Type [2] and [Enter]. The Insert block menu will be displayed again. Type [O] for ok and the 100 point block segment buffer will be repeated twice starting from the point 599. To increase the horizontal display range from 600 to 1200 points type [>]. The display should be as shown below:



Edited Waveform

Figure 19

Deleting a Waveform Segment

Block actions include the capability to delete selected segments of the waveform. The deleted segment is automatically placed in the block buffer.

Starting with the waveform which we modified in the previous section, we will delete the 100 point waveform block starting at point 200.

1. If not already in the Block Actions menu, press the function key [F4] to return to the system menu. Type [E] to enter the **Edit** mode, followed by [W] for **Wave Edit**. **Block Actions** are then initiated by typing [B], as before. Type [D] to select the **Delete** operation. The Delete menu will appear:

```
Delete block:   Mode        Start   durationN      To          Ok
(to buf)        Wave          600       100      699
                          (600.0 us) (100.0 us) (700.0 us)
```

NOTE: If you have used EASYWAVE for another purpose since completing the block insert activities in the previous section, the Start, durationN, and To values may differ from what is shown above.

2. Type [S] to select the starting point of the segment to be deleted. The following menu will appear:

```
Starting point: (0 to 799) [600]:_
C to get from cursor
```

3. Type [200] and [Enter] to set the starting point to 200. The **Delete block** menu will reappear.
4. Type [T] for **To** to select the end point.

```
End point: (200 to 799) [299]:_
C to get from cursor
```

5. Type [300] and [Enter]. *EASYWAVE* will return to the Delete block menu, which shows instructions for deleting the 101 points between 200 and 300.

6. Type [O] for Ok, and the waveform segment between point 200 and point 300 will be deleted. The segment from 301 to 599 will move to the left to fill in the deleted section.

The deleted waveform segment has been saved in the block action buffer. At this point it is possible to undo the deletion by doing an **Insert from buffer** operation. Once any other block action operation takes place the buffer will be overwritten and the deleted waveform segment will be lost.

Vertically Moving a Waveform Segment

The Block Action menu offers users the ability to modify waveforms by varying DC offset with a **Vertical move** capability. It also enables use of a Scaling mode to compress or expand the vertical and/or horizontal axis.

The damped sine waveform created earlier in this tutorial will be used to demonstrate vertical moves. This 600 point waveform is a damped sine wave defined by the equation:

SIN(2*PI*T/30)*EXP(–T/100)

1. Reconstruct this waveform (0 to 600 points) using the equation editor, or by recalling it from disk where it was stored as LINK2.WAV. Press [F4] to return to the system menu. Select the **Edit** mode by typing [E], then [W] for **Wave edit.**

NOTE: If the waveform display does not appear on screen, press [F3] and then [1] to cause the display to be shown.

The current display in *EASYWAVE* Channel 1 is now a damped sine wave from point 0 to 599. This waveform will be modified here using the Vertical Move capability, and then, in the next section, with the *EASYWAVE* Block scale operations. Type [B] to enter the **Block actions** mode.

2. Type [V] from the Block menu and the **Vertical move** menu will be displayed:

Vertical move:	Start	duratioN	To	Value	Direction	Ok
(to buf)	200	100	299	0	up	
	(200.0 us)	(100.0 us)	(300.0 us)	(0.000 V)		

If the Start, duratioN, or To values differ from values displayed above, type S, N, or T and enter the numbers as shown above.

2. To adjust the vertical DC offset of the selected waveform segment, *i.e.*, points 200 to 299, type [V] for **Value**. The **Vertical move value** prompt will appear.

```
Vertical move value (0 to 255) [0]: _
```

Note: The maximum vertical move depends on the particular AFG.

3. Type [50] and press [Enter]. The Vertical move menu will reappear with a Value field entry of 50. Typing [O] for OK will move the selected waveform segment upward by 50 points.
4. Type [D] for **Direction**, and the Direction field of the Vertical move menu will change from up to down. Typing [O] will result in the selected waveform segment being translated downward by 50 points from the original position. Vertical moves are all defined relative to the original vertical position of the defined segment.

The following sequence of actions will restore the defined segment to its original vertical position:

1. Type [V] to enter a vertical move **Value**.
2. Press the zero [0] key and [Enter], to set the offset value to zero.
3. Type [O] for **Ok** to confirm and execute the vertical move.

Keep in mind that once the data segment for a vertical move is defined, a copy of the original data is stored in the block action buffer. Each time a vertical move is made, this original data is retrieved from the buffer and the specified value is added or subtracted based on the direction setting. Thus a vertical move of 0 will restore the waveform.

Vertical Scaling

Compression and expansion of a selected waveform segment is controlled from the Block action Scale field. We will continue to use the section of the damped sine wave defined previously, extending from points 200 to 299.

1. Return to the Block menu by pressing the [Esc] key.
2. Type [S] for Scale. The Scale menu will be displayed as shown below:

Scale:	Mode	tYpe	Start	duratioN	To	fiXed	Factor	ok
(to buf)	wave	vert'l	200	100	299	128.00	1.00	
			(200.0 us)	(100.0 us)	(300.0 us)	(3.92 mV)		

The type field, **vert'l**, indicates that the selected waveform segment will be scaled vertically. The segment is defined by the Start and To fields. In this case the segment starts at 200 and extends to 299. The limits of the segment are indicated on the *EASYWAVE* display by the markers, dashed vertical lines, at the start and end point of the segment.

Vertical scaling modifies the amplitude of each point in the defined waveform segment according to the following formula:

New amplitude = ((old amplitude – fixed)* factor) + fixed

Where:

factor is the value of the **Factor** field in the **Scale** menu.

fixed is the value of the **fiXed** field in the **Scale** menu. In most cases this will correspond to the current zero reference value of the waveform. This is the equivalent of the DC offset of the waveform.

old amplitude value is the amplitude of a specific data point before scaling.

new amplitude is the amplitude of a specific data point after the scaling operation.

This formula allows vertical scaling about a fixed amplitude level, which will be maintained at the same value before and after the scaling operation.

3. Use the cursor keys (←, →) to move the display cursor to the first positive peak in the defined waveform segment. The cursor readout should appear as shown:

Cursor: 218 (218.0 us), 135 (58.8 mV)

4. Type [F] to enter the **Factor** value. The factor menu will be displayed:

Factor for vertical scaling (-100.00 to 100.00) [1.00]:

5. Type [2] and press [Enter]. The scale menu will be displayed with the factor field value changed to 2.00.
6. Type [O] for **OK** and the defined waveform segment will be redrawn with increased vertical amplitude swing.
7. Press [INS], the insert key, to display the cursor annotation. *Note that the cursor amplitude is now 142.*

   The value of 142 was obtained from the previous value of 135 as follows:

   new value = ((135–128)* 2)+ 128 = 142
8. To restore the waveform segment to its former amplitude range: Type [F], and in response to the Factor menu type [1] and press [Enter]. The Scale menu will reappear, type [O] for **OK** and the waveform will be re-scaled to its original values.
9. Type [INS] to display the cursor reading and verify that the cursor value is 135 again. The factor value of 1 will restore the selected segment to its previous value.

NOTE: as in the case of the vertical move operations, scaling retrieves the original data from the buffer and applies the formula using the current factor and fixed parameters. Therefore, repeated scale operations do not accumulate inaccuracies.

Scaling the waveform to a selected amplitude range requires entering the desired new and old values into the equation:

New amplitude = ((old amplitude – fixed)* factor) + fixed

Scaling our currently selected value (point 218) to the full scale range value of 255 would require a Factor value of:

255 = ((135 – 128)* Factor + 128)

solving for the Factor value we have:

Factor = (255 – 128)/(135 – 128) = 18.14

10. Type [F], then type [18.14] and press [Enter]. *EASYWAVE* will respond by setting the Factor value in the Scale menu to 18.14.

11. Type [O] for Ok to initiate the scaling operation. Press [INS] to obtain the cursor annotation. The cursor amplitude readout will indicate 255, the maximum amplitude value.
12. To restore the waveform segment to its former amplitude range, Type [F]. In response to the Factor menu, type [1] and press [Enter]. The Scale menu will reappear.

    Type [O] for OK and the waveform will be re-scaled to its original values. Return to the Block menu by pressing the [Esc] key.

Notes: 1. The full scale varies with the particular AFG.
2. The factor can be entered as a ratio, e.g., 127/7.

Horizontal Scaling

Horizontal scaling uses a similar series of operations to expand or compress the selected waveform segment in the horizontal direction. We will demonstrate this by continuing to use the damped sine wave.

1. Starting from the Block menu, Type [S] for Scale.

At this point the Scale menu will be displayed:

Scale:	Mode	tYpe	Start	duratioN	To	fiXed	Factor	ok
(to buf)	wave	vert'l	200	100	299	128.00	1.00	
			(2000.0 us)	(100.0 us)	(300.0 us)	(3.92 mV)		

If the Start, duratioN, or To values differ from values displayed above, type S, N, or T and enter the numbers shown above.

2. Type [Y] to select **Horizontal interpolated** scaling. The Scale menu tYpe field will change as shown below:

Scale:	Mode	tYpe	Start	duratioN	To	Buffer	Factor	ok
(to buf)	wave	horiz interp	200 (2000.0 us)	100 (100.0 us)	299 (300.0 us)	100 (100.0 us)	1.00	

3. We are still using the waveform segment starting at point 200 and extending to 299.
4. Type [F] then [2] followed by [Enter] to set the Factor value to 2. The Scale menu will be displayed again with the Factor value now set to 2.00.
5. Type [O] for Ok to expand the selected segment horizontally over the range of 200 to 399.

6. Set the Factor back to 1 and tYpe [O] again to compress the waveform segment back to its orignal 200 to 299 range.

STORING A WAVEFORM CAPTURED BY A LECROY OSCILLOSCOPE

Where no equation or numeric description is available, a valuable asset for generating waveforms is the ability to transfer measured waveforms from a digital oscilloscope, digitizer, or transient recorder.

EASYWAVE can acquire waveforms directly from a LeCroy Oscilloscope. Once acquired, such waveforms can be used directly, or modified by use of the C and D array variables in the equation editor.

NOTE: EASYWAVE can also translate waveform data files from LeCroy digitizers and transient recorders which have been stored using the CATALYST program. File translation is handled by a utility program, CATWAV, which is supplied on the EASYWAVE Waveform Sampler and Utility disk. Instructions for the use of CATWAV are contained in Appendix B.

Oscilloscope/ AFG Setup

Before attempting to capture and transfer a waveform from a LeCroy oscilloscope make certain that the AFG, Scope and computer are connected using appropriate GPIB cables.

Then, check to be sure that the Scope and the AFG are set to the GPIB (IEEE-488) addresses listed in the *EASYWAVE* Configure mode menu. The Configure mode menu is accessed from the *EASYWAVE* system menu by typing [C] followed by [Enter]. The Configure mode menu will appear as shown below:

Configure:	Gpib	Name	Afg	Type	Scope	tYpe	dMa	Join	dots	Help	Colors
	0	GPIB0	1	9100 AFG	4	9400 Scope	on		off	on	

The AFG GPIB address setting default value is 1. The oscilloscope default address is 4. If the addresses on either instrument rear panel GPIB switch differs from the listing in the *EASYWAVE* Configure mode menu, one setting or the other will have to be changed to bring them into agreement.

NOTE: If you change the rear panel settings on either the AFG or the oscilloscope, cycle the power switch of that instrument from off to on to update its GPIB address.

Changing the GPIB address in *EASYWAVE* is accomplished by typing [A] to change the AFG address or typing [S] to change the Scope address. In either case *EASYWAVE* will request a numerical address in the range of 0 to 15.

Each instrument on the bus, including GPIB, must have an exclusive address. Enter the desired address and press [Enter]. When the updated Configure mode menu appears, verify the new addresses, if any, and return to the System menu by pressing [F4].

This completes the initial setup of the instruments. The desired waveforms can now be captured using the Scope in the single trigger mode. Waveforms stored in Channel 1 and/ or Channel 2 of the Scope may be transferred into the AFG.

Transferring the Captured Waveform(s)

Acquiring a captured waveform in *EASYWAVE* is a file transfer operation. Starting from the *EASYWAVE* system menu type [F] for File transfer. The File Transfer menu will appear on the screen.

File transfer:	Disk to ew	dIsk to afg and ew	Ew to disk	eW to afg	Afg to disk and ew	aFg to ew	More

The menu entry More indicates that there are additional selections. Type [M] to see these items. The menu More files will appear:

More files:	Delete disk	dIr dIsk	dElete afg	diR afg	Get from scope	Merge .WV1,.WV2	Current dir \EW

Press [G] and the Get from dso menu will appear:

Get from Scope:	Type 9100 Scope	tYpe 9400 Scope	Scope channel 1	Easywave channel Ok 1

Typing [S] will alternate the **scope channel** selection between Channels 1 and 2. Typing [E] will alternately select

the destination **Easywave channel**. The default settings will transfer the waveform from Channel 1 of the scope into Channel 1 of *EASYWAVE*.

The transfer can be started by pressing the [O] key to signify that it is **Ok** to begin the transfer. When the transfer is complete, the appropriate *EASYWAVE* wave display channel will appear with the transferred waveform.

In addition to the actual waveform data, the data descriptor of the oscilloscope waveform is read to determine the amplitude, offset, and time base of the waveform. These parameters are used to adjust the *EASYWAVE* channel amplitude and offset settings as well as the stored clock period and rate settings in *EASYWAVE*. This will properly scale the amplitude and time readouts in units of volts and seconds.

If the Scope's effective sampling rate exceeds the maximum clock rate of the AFG, *EASYWAVE* will allow you to drop points from the data so the AFG can reproduce the wave with correct timing. You will alternatively have the option of keeping all the data points, but in that case the AFG will not be able to reproduce the waveform at the appropriate speed.

If any difficulty is encountered in transferring the captured waveform, an appropriate error message such as:

No response from Scope. If Scope remote still on, trigger it

will appear.

If transfer from the LeCroy Scope is not readily achieved, however, check GPIB addresses and GPIB cable connections; improper addressing and cable hookup are typical causes of problems in transfer from the Scope.

Once the waveform has been transferred in, it can be manipulated like any other waveforms within *EASYWAVE*. Earlier sections describe the transfer and loading of waveforms from *EASYWAVE* to the LeCroy AFG

CREATING, STORING AND EXECUTING SEQUENCE FILES

Performing a succession of macro operations such as loading and linking waveform segments can be automated through the use of sequence files. Sequence files operate in the AFG much the same way as batch files in a personal computer.

To run a sequence file, the relevant waveform and settings files used by the sequence file must first be transferred to file memory within the LeCroy AFG. Then, the sequence file capability can be used to batch commands and automate the creation and modification of complex waveforms.

A sequence file can use any of the GPIB commands contained in Appendix D. An example of using sequence files follows. Additional information about sequence files can be found in Section 7 of this manual.

One example of the use of sequence files is to generate a data communications protocol for transmitting selected letters from a keyboard. Baudot or ASCII could be used for this purpose, but the example that follows will use the Morse code as a protocol.

The International Morse code consists of long, short, and space elements that are called dash, dot, and space respectively. Every character is represented by a unique combination of dots, dashes, and spaces. Each such combination can be encoded in a sequence file, one for each character.

The Dot, dash, and space elements, however, are in practice stored as waveforms:

- **The dot element** is a sine burst of fixed length followed by an equal length waveform at a zero level for an inter–element space.
- **The dash element** is a sine burst three times the dot length, with an identical inter–element space.
- **The space element** is a zero level, with a length equivalent to the Dash element, and is used for inter–character spacing.

To create letters, these waveforms must be loaded into the AFG file memory. This can be done in the manner described in the foregoing examples. Presume that the dot waveform is named DOT.WAV, the dash waveform DASH.WAV, and the space waveform SPACE.WAV.

In Morse code, the letter A consists of a dot followed by a dash. A space is then necessary to separate the dot–dash combination from any letters that follow. To generate an A, therefore, requires a dot, followed by a dash, followed by a space.

In terms of waveforms, this is accomplished by loading DOT.WAV, linking DASH.WAV and then linking SPACE.WAV. After the three waveforms are loaded and linked, the Go command must then be given so that the AFG will execute the desired waveform sequence.

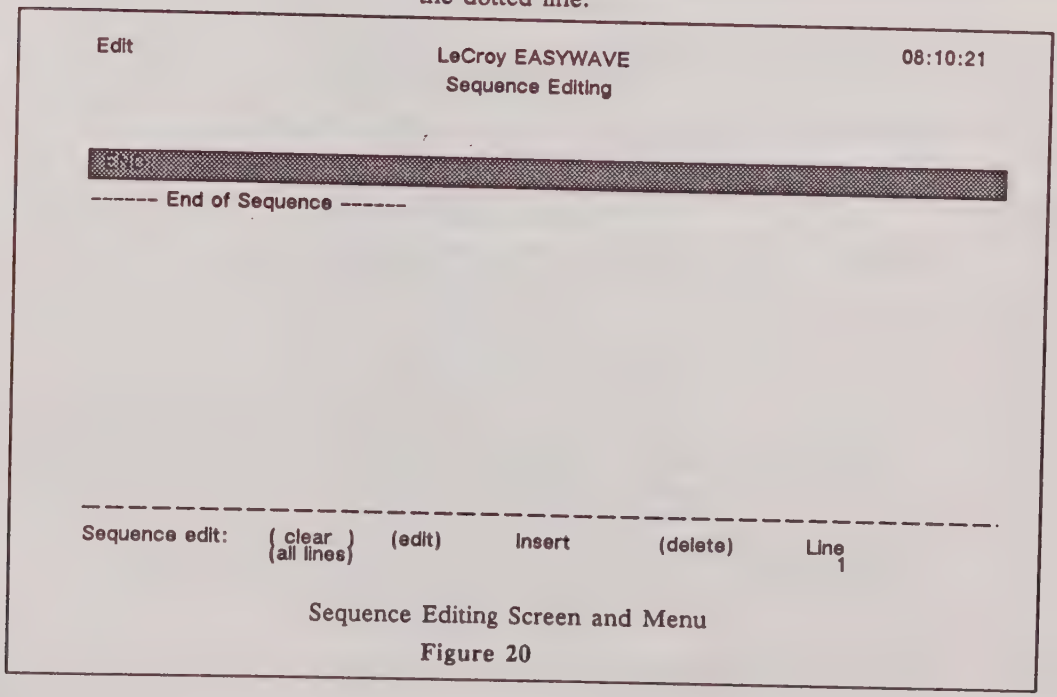
This sequence can be accomplished by using *EASYWAVE* as described above to load and link each character's waveform representation.

Alternatively, a sequence file can be used. The sequence file to generate the letter **A** is:

```
abort;
load dot.wav,1;
link,dash.wav,1;
link,space.wav,1;
go;
end;
```

This sequence file is created, stored, and executed as follows:

1. Access the system menu by typing [F4].
2. Type [E] to go into Edit mode, and then type [Q] to perform sequence editing. The sequence edit menu will appear (Figure 20).
3. Type [I] for Insert and a blank line will appear below the dotted line.



Sequence Editing Screen and Menu

Figure 20

4. Type [abort;]. This command will terminate any existing waveform generation and is generally included if you wish to start a new sequence.

   As you type, what you type will appear on screen below the dotted line. Press [Enter] and the typed material will move to the top of the screen, above the END; command.

NOTE: The entries in a sequence line are separated by by spaces or commas, with the line ending in a semicolon. More than one command may be placed on a line, however, we have not done that for the sake of readability.

The line: load,dot.wav,1;

commands the AFG to load the waveform named dot.wav, with a repetition count of one (the waveform is executed once).

In this regard, the letter **H**, which is represented by four dots, would in *EASYWAVE* be entered as **load,dot.wav,4;** followed by **link,space.wav,1;** followed by the **go** and **end** commands.

5. Type [load,dot.wav,1;] and [Enter]. The second line in the sequence will be appear as the second line at the top of the screen.
6. Type [link,dash.wav,1;] and [Enter]. Now there will be three sequence lines at the top of the screen.
7. Type [link,space.wav,1;] and [Enter]. This is the fourth line of the sequence file.
8. Type [go;] and [Enter]. This causes go; to be displayed as the fifth line at the top of the screen.
9. Including END; six lines of the sequence are now at the top of the screen.
10. Press [F4] to go back into the system menu, and [F] to access the File transfer mode.
11. Type [E] for **EW to disk** to transfer the sequence file from *EASYWAVE* to PC disk. When the **EW to disk** menu appears, type [Q] for **seQuence**. A disk directory of sequence files will be displayed.
12. Type [MORSE] and [Enter]. The sequence created in steps 4 through 9 is now stored on PC disk as the file MORSE.SEQ. The File transfer menu will again appear at the bottom of the screen.
13. Select **dIsk to afg and ew** by typing [I] to transfer the sequence file from the disk to the AFG. When the **Disk**

to AFG menu appears, type [Q] for seQuence. The prompt

```
Get sequence file from disk – name [MORSE.SEQ]:_
```

will appear. Press [Enter]. The sequence is now stored in the AFG file memory.

14. Press [F4] to access the system menu. Once there, type [O] to go into the **Operate** mode. After the Operate menu appears, type [A] to bring up the **Operate arbitrary** menu. From that menu, press [A] for the **Afg action** menu. Then, select **run seQuence file** by typing [Q].

    A directory of sequence files, resident in the AFG memory will be displayed, with MORSE SEQ highlighted. Type [Enter] and the file will be executed.

NOTE: The waveforms illustrated above have the same settings. Sequence files can also be used to control the AFG settings. Here is an example of a sequence file that implements a series of settings changes as well as the loading operation.

```
ABORT;
C1A,5V;
C1O,0V;
C1Z,128;
C1P,ON;
SUM_MODE,OFF;
C2P,OFF;
CSOU,INT;
CPER,5NS;
TMOD,CON;
TAS,AUTO;
TSOU,BUS,ON;
TDEL,4;
MDEL,4;
LOAD,SIN100.WAV,1;
WAIT;
GO;
END;
```

The commands used in sequence files are identical to the GPIB remote commands. A summary of these commands is given in Appendix D. A detailed description of each command is given in the AFG Operating Manual.

ACTION HLP	lists instrument actions that can be invoked in the Operate mode.
ARBTRARY HLP	discusses the submenu obtained by going into Operate mode and then into the listing entitled "Arbitrary generator".
ARRAY HLP	explains Edit Wave Array editing in wave mode.
ARYLOGIC HLP	explains Edit Wave Array editing in logic mode.
ASCIIWAV HLP	explains using ASCII .DAT files to input waves into EASYWAVE.
BLOCK HLP	shows how block editing works in the Edit mode.
BLOCKS HLP	gives more information about block editing.
CHANSET HLP	defines channel setting parameters.
CLKRATE HLP	explains which clock rates are attainable.
CLOCKSET HLP	defines the clock setting parameters.
CONFIG HLP	defines the items listed in the Configure menu.
DAMPSINE HLP	provides information about specifying damped sine waves in the simple elements portion of the Wave Edit menu.
DCSTEP HLP	offers details on specification of DC/step waveforms in the simple elements portion of the Wave Edit menu.
DISPLAY HLP	lists the display menu options available after pressing [F3].
DSOEW HLP	explains the **Get from dso** option contained within the second part of the File transfer main menu.
EDIT HLP	describes the Edit mode main menu.
EDITSEQ HLP	explains the options available for sequence editing.
ELEMENTS HLP	identifies the types of simple element editing allowed in the Edit mode.
ELEMMORE HLP	gives information about the second portion of the simple element help screens.
EQUEXAMPL HLP	gives examples of equations.
EQUATION HLP	provides information about equation entry.
EXPONENT HLP	explains the parameters involved in specifying exponential waveforms in the simple elements portion of the Wave Edit menu.
FILE HLP	explains File Transfer menu.
FILEMORE HLP	explains the "More" command on the File Transfer menu.
FILES HLP	gives information about file types.
FRQSWEEP HLP	defines the parameters that must be selected in specifying frequency sweep waveforms in the simple elements portion of the Wave Edit menu.

FUNCMORE HLP	identifies lower level function generator menu in the Operate mode.
FUNCTION HLP	defines the function generator menu in the Operate mode.
GAUSSIAN HLP	defines the parameters unique to specification of Gaussian waveforms in the simple elements portion of the Wave Edit menu.
GPIBPROB HLP	gives suggestions on what to do if *EASYWAVE* encounters a problem in communicating with the AFG or DSO.
KEY HLP	is a reminder about which keys perform which tasks.
LOADLINK HLP	explains the load and link capabilities that are a part of the Arbitrary Generator Waveform menu within the Operate main menu.
NUMBER HLP	shows how numbers are entered in *EASYWAVE*.
OPERATE HLP	describes the options provided by the Operate main menu.
PREVIEW HLP	explains previewing in Edit Mode.
PULSE HLP	lists the pulse generator submenu in Operate mode.
RAMP HLP	identifies the parameters involved in specifying a ramp waveform in the simple elements portion of the Wave Edit menu.
RUNSEQ.HLP	explains the options available when running a sequence file.
SEQUENCE.HLP	discusses sequence files.
SINE HLP	provides information about specifying sine waves in the simple elements portion of the wave edit menu.
SQUARE HLP	defines the parameters used in the specification of square waves in the simple elements portion of the wave edit menu.
SYSTEM HLP	describes the system menu.
TRIANGLE HLP	offers information about the specification of triangle waveforms in the simple elements portion of the wave edit menu.
TRIGSET HLP	lists the trigger and delay setting capabilities.
WARNINGS HLP	indicates important points to be aware of.
WAVEDISP HLP	lists the specific keys used to move the cursor and modify the wave display.
WAVEEDIT HLP	enumerates the ways by which a wave can be changed.

A copy of each help screen follows in the same alphabetical order used above to define the help screen designations.

ACTION.HLP

Action menu:

Setup afg from file	Set up all settings from the specified settings file in the LeCroy AFG file memory.
run seQuence file	Run the specified sequence file, resident in the AFG file memory, until encountering the WAIT command or the end of the Sequence file. See RUNSEQ.HLP
Go	Generate the wave in the high-speed (waveform) memory, waiting, if necessary, for aRm trigger and Trigger.
Abort wave	Abort wave generation.
aRm trigger	Arm the trigger (single and burst modes only).
Trigger	Send the trigger (single and burst modes only).

ARBTRARY.HLP

Menus in OPERATE Mode, Arbitrary function generator

Load wave clear high-speed memory and move wave from AFG file memory (non-volatile, RAM disk) to high-speed memory, see LOADLINK.HLP.

Link wave move another wave of same type (single or dual) to high-speed memory (if not already there) and link it in.

Settings change change any LeCroy AFG setting:
for channel settings see CHANSET.HLP
for clock settings see CLOCKSET.HLP
for trigger and delay settings see TRIGSET.HLP.

leaRn setup from active AFG settings to AFG file memory, specify name.

Afg action request AFG actions, see ACTION.HLP.

ARRAY.HLP

In Edit Wave Array wave mode points can be inserted, deleted or changed. See ARYLOGIC.HLP for Edit Wave Array logic mode.

1. <F5> toggles entry and display (points vs seconds, point value vs volts.
2. 'Mode' switches mode to logic mode (with the corresponding menu).
3. The point to be changed can be chosen by <Home>, <End>, <PgUp>, <PgDn> and arrow keys, or by 'P' plus numeric input.
4. The value can be entered using 'V' or not. Any numeric entry (without preceding 'P') will be treated as a value entry. To enter a negative number, however, 'V' must be typed before '–'. Number entry can be terminated by <Enter> or by an arrow key to get to another point.
5. The '+' ('–') key raises (lowers) the value at the backlit point by 1.
6. deLete deletes the backlit point.
7. Insert toggles insertion. If insert is on points are inserted.
8. Radix toggles between base 10 and base 16, allowing decimal or hexidecimal input and display. In base 16 <F5> allows binary instead of volts.

ARYLOGIC.HLP

In Edit Wave Array logic mode bits can be inserted, deleted or changed. See ARRAY.HLP for Edit Wave Array wave mode.

1. 'Mode' switches mode to wave mode (with the corresponding menu).
2. The Point and bit posN to be changed can be chosen by <Home>, <End>, <PgUp>, <PgDn> and arrow keys (re table). The bit can also be chosen by numeric input of point and bit. <F5> toggles between points and seconds.
3. Numeric entry can be terminated by <Enter> or by an arrow key to get to another point or bit.
4. Use 'V' to enter the point value in binary.
5. Toggle the bit value via 'B', or enter it directly via '0' or '1'.
6. deLete deletes one bit at the selected bit number and point, moving the remaining bits up one point each and replacing the last bit with x.
7. Insert (called after point and bit number have been selected) requests value of the bit to be inserted.

ASCIIWAV.HLP

Wave files in ASCII format can be loaded by EASYWAVE in File transfer, "Disk to ew" or "Disk to AFG". If a file name with extension ".DAT" is entered, EASYWAVE assumes that the input wave file will be in ASCII format and the translation will be appropriate for the AFG type.

The file should simply be a list of decimal ASCII points separated by commas, spaces, carriage returns or other non-numeric separators. Values should be 0 to 255 for an 8-bit AFG, 0 to 4095 or 65535 for other AFG's.

Below are two examples of 8-point .DAT waveform files:

123, 3400, 47, 2406, 675, 688, 65, 113 or

123 3400 47 2406
675 688 65 113

BLOCK.HLP

Block actions treat a block of points (or bits if logic mode) of a wave. The first action of any type or change of Mode or Start (or Buffer length in Horizontal Scale) fills the block buffer, so the original points (bits) are not lost, and can be retrieved. Delete can be reversed by Insert, Vertical move can be reversed by moving with value 0, Scaling can be reversed by rescaling with a factor of 1.00. For additional safety save a block to disk.

Other actions (without leaving the particular function) perform operations on the original points (bits) in the block buffer. The menu says "(to buf)" when new points will be put in the buffer, or "(replace)" when points will be replaced from the buffer, with the action requested. If replacement is not wanted, hit <Esc>. Then the buffer contents can be Inserted.

In Logic mode Put in buffer, Delete, Insert, inVert and Scale horizontal are implemented. The maximum size of the buffer is 32768 for 8-bit AFG's, 16384 for other AFG's. Also see BLOCKS.HLP.

BLOCKS.HLP

From disk brings a wave in from disk and puts in the block buffer, inserting it in the wave.

To disk stores any selected part of the wave on disk and also puts it in the block buffer, leaving the wave unchanged.

Put in buffer puts selected points (or bits) of the wave in the block buffer, leaving the wave unchanged.

Delete deletes some points (bits) of the wave and puts them in the buffer, (reducing the size of the wave in wave mode and reducing the size of the selected bit in logic mode). The action can be reversed by inserting the points (bits).

Insert inserts points (bit values) from the buffer into the wave (bit) at the selected Start, increasing the size of the wave (bit).

Vertical move moves the selected part of the wave up (or down). The first move puts the selected part into the block buffer and moves that part of the wave up (or down) relative to the buffer. Subsequent moves by changing value only leave the buffer unchanged and move just the selected part. Setting the value to 0 restores the wave to its original state.

Scale vertical adjusts the height of points in the wave piece. The first scaling (or change of Start) puts the selected part into the block buffer and then scales that part of the wave. The part in the buffer remains unchanged. The number of points in the wave also remains unchanged. The scaling factor can be negative or entered as a ratio. Negative scaling factors flip the segment top to bottom. Setting the factor to 1.00 restores the wave to its original state.

Scale horizontal whether interpolated (floating point or integral factors) or repeated (integers only) horizontal scaling adjusts the number of points. The first horizontal scaling (or change of Start, Buffer size or scaling mode) puts the selected part of the wave into the block buffer. When the segment is scaled the buffer keeps the original data. Subsequent scalings use the data in the block buffer and apply the

factor to the buffer length to determine the new number of points. The scaling factor can be negative or entered as a ratio. Negative scaling factors reverse the segment from left to right. Setting the factor to 1.00 restores the wave to its original state.

InVert bits inverts bits in logic mode.

The maximum size of the buffer is 32768 for 8-bit AFG's; 16384 for other AFG's.

CHANSET.HLP

For Channel 1 and Channel 2 (if dual channel AFG):

Amplitude	Peak to peak amplitude. See AFG manual for limits.
Offset	Voltage offset. See AFG manual for limits.
Zero Ref	Point value between 0 and MaxData corresponding to the Offset. Volts = Offset + (Point value – Zero Ref) * Amplitude / MaxData.
Filter	Off or 1 MHz, 3 MHz, 10 MHz, 30 MHz or 100 MHz (8–bit AFG's only).
Output	Output is on or off.
Invert	Inverts wave data (in 8–bit AFG's can use with Sum Mode to get difference)
Load Comp	Load compensation of output voltage (not in 8–bit AFG's)
Dig Word	Digital word outputs on or off (not in 8–bit AFG's). Always on in AFG Model 9109.

Just Channel 1 in 8–bit AFG's:

Sum Mode	Channel 2 is summed into Channel 1 of the LeCroy dual–channel AFG.
Ext Sum	An external signal is summed into Channel 1 of the AFG.

CLKRATE.HLP

The clock rate will always be within 0.035% of any user requested frequency. However, some clock rates are accurate to 5 ppm. These are produced by a combination of Voltage Controlled Oscillators (VCO) and a binary divide chain.

The VCOs produce frequencies from 100 MHz to 200 MHz in steps of 62.5 KHz, i.e., in MHz: 100, 100.0625, 100.125, ... 128.0, ..., 150, ... 200

Lower frequencies are achieved by dividing by a power of two. In particular, any axact multiple of 1 MHz will be accurate to 5 ppm. For 5 kHz the closest frequency the AFG will try to generate will be 4.999161 kHz.

A utility program CLKRATE.EXE (included with EASYWAVE) will show the actual clock rate for any user requested rate.

CLOCKSET.HLP

Clock settings

Mode	Master or slave clock available on 8-bit AFG's version 1.100 or later and all versions of other AFG's.
Period	LeCroy AFG clock period. See AFG manual for limits.
Rate	The inverse of the clock period.
Source	Clock source, internal or external.
Level	Voltage threshold level for external clock source.
Slope	Active edge of external clock source.
Reference	Reference clock, internal or external.

CONFIG.HLP

Menu in CONFIGURE Mode

Gpib	the GPIB address for the PC to use, default = 0.
Name	the name of the GPIB board, default GPIB0, other GPIB1.
Afg	the GPIB address of the LeCroy AFG, default = 1.
Type	Selects AFG Model. If 9101 AFG, no channel 2 settings needed. If no AFG, allow menus in Operate mode without any AFG connected. Also selects 12 or 16-bit data format for 9112 AFG.
Scope	the GPIB address of the LeCroy Scope, default = 4.
Type	9400, 9420, 9450 or No Scope. No Scope allows Get from Scope menu without any Scope.
dMa	default is as set in GPIB.COM using IBCONF. Can be turned off in *EASYWAVE* if PC2A board or PC clone needs it off. If (dma) then DMA is turned off in GPIB.COM and cannot be turned on in *EASYWAVE*. Returns to GPIB.COM setting when leave *EASYWAVE*.
Join dots	if yes, join data-point dots together with lines.
Help	if on, get automatic help screens first time in any menu.
Colors	if color screen, select colors.

These changes are saved on disk and thus permanent until further change by the user.

DAMPSINE.HLP

The simple element damped sine allows selection of:

Frequency	frequency of the damped sine, based on current values of the Clock rate (or period) in the *EASYWAVE* settings file.
Period	period of the damped sine (the inverse of the sine frequency).
Cycles	the number of cycles of the damped sine wave.
Start phase	the starting phase of the sine wave in degrees.
Time const	total time of the damped sine wave.
More	other parameters, common to all simple elements, see ELEMMORE.HLP.

<F5> switches entry and display (points vs seconds, point value vs volts)

DCSTEP.HLP

The simple element Dc/step allows selection of:

Width/step	width per step.
Steps	number of steps, 1 less than the number of levels.
Levels	number of levels, 1 more than the number of steps.
Total time	total time of the steps, width times number of levels.
sloPe	step sloPe, toggled positive or negative.
More	other parameters, common to all simple elements, see ELEMMORE.HLP.

<F5> switches entry and display (points vs seconds, point value vs volts)

DISPLAY.HLP

Display can be chosen for:

Settings settings file in *EASYWAVE* memory

seQuence sequence file in *EASYWAVE* memory

Mode wave or logic mode for wave file
1st ch Channel 1 wave file only
2nd ch Channel 2 wave file only
Both Channels 1 and 2 in the same display (if not logic or volt & sec)
Dual Channel 1 above channel 2, two graphs
miXed Channel 1 wave and logic for 12-bit AFG only

In wave display additional choices (in points or seconds) are:

Offset Offset of wave display in points or seconds via <F5>
Cursor Cursor position in points or seconds
(value) value of the wave at the cursor position (in volts or codes)
durationN durationN of the display on the screen. Any number between 50 and 66000 (or 33000 for Model 9112) can be chosen but will be raised (if necessary) to be 50, 60, 75, 100, 120, 150, 200, 300, 600 or some multiple of 600.

DSOEW.HLP

1. The type of AFG and type of Scope can be changed but will revert to the permanent default type entered on the Configure Menu when reboot.
2. LeCroy Oscilloscope files from channel 1 or 2 can be read to EASYWAVE channel 1 or 2.
3. The amplitude, offset, and time base are also read.
4. If the time base is less than 5 nsec/pt for an 8-bit AFG or 20 nsec/pt for other AFG's, the user can choose to keep all the points or to compress the data so the wave will take up the same time when generated by the AFG.
5. The amplitude is stored in Channel 1 (or 2) Amplitude, the offset in Channel 1 (or 2) offset and the time base is stored in Clock Period, with its inverse in Clock Rate.

EDIT.HLP

EDIT mode allows modification of the principal files of the LeCroy AFG:

Settings file Contains all the AFG settings –

for channel settings – see CHANSET.HLP.

for clock settings – see CLOCKSET.HLP

for trigger and delay settings – see TRIGSET.HLP..

Sequence file Contains a list of AFG commands – see SEQUENCE.HLP

Wave file Contains AFG wave points, which can be created and changed in many ways. See WAVEEDIT.HLP.

NOTES: *For numeric entry see NUMBER.HLP*

In EDIT mode EASYWAVE does not communicate with the LeCroy AFG except for previewing – see PREVIEW.HLP

<F1> for help screens
<F2> for principal menus
<F3> to change display
<F4> for System Menu
<F5> for toggle units
<F6> to Preview
<Esc> to exit

EDITSEQ.HLP

Clear all lines	clears all lines in file, after checking.
Edit	edit an existing line with a plain text line editor, but if past the last line, insert until <Esc>.
Insert	insert new lines at the cursor, until <esc>.
Delete	delete line at the cursor.
(line)	shows line number, selected with cursor.

Can use Backspace, Del, left arrow [←], right arrow [→], <Ctrl> left arrow (to get to start of an edit line) <Ctrl> right arrow (to get to the end of an edit line) while modifying a line.

See also SEQUENCE.HLP and RUNSEQ.HLP

ELEMENTS.HLP

Simple element editing allows some familiar wave shapes to be calculated using usual parameters instead of writing an equation. The elements currently available (and their HELP files) are:

Sine : SINE.HLP	Dc/step :DCSTEP.HLP	Exponential :EXPONENT.HLP
sQuare : SQUARE.HLP	Triangle :TRIANGLE.HLP	daMped sine :DAMPSINE.HLP
Ramp : RAMP.HLP	Gaussian :GAUSSIAN.HLP	Frequency sweep :FRQSWEEP.HLP

<F1> for any help screen,
<F2> for principal menus
<F3> to change display

<F4> for System Menu,
<F5> for toggle units
<F6> to Preview.

<Esc> to exit

Note: To generate waves as specified, the EASYWAVE settings must be sent to the AFG and setup when the wave is loaded. Generally save the settings with the same name as the wave to simplify the task.

ELEMMORE.HLP

Each simple element has a choice of More which allows selection of:

Start	Starting point in points or seconds
Low	Low point or voltage value.
High	High point or voltage value.
Insert	Insert toggle to decide whether to insert a new part into the wave or overwrite the existing wave.
Ok	To calculate the new points when all parameters are OK.

<F5> switches entry and display (points vs seconds, point value vs volts)

EQEXAMPL.HLP

`SIN(2*PI*S/40e-6);` sine with a 40 usec cycle

`SIN(2*PI*T/30)*exp(-T/100);` damped sin 30-point cycle, 100 pt time constant

`R1*EXP(-S/1e-3);` equation in R1, damped with 1 msec time constant

`R1*STEP(1E-3-S)+R2*PULSE(S,1e-3,3e-3);` equation in R1 from 0 to <1 msec; and then the equation in R2 from 1 msec to <3 msec

`R1*STEP(100-T) + R2*PULSE(T,100,300);` similarly for Time in points assuming a 10 usec clock rate

`R1*(1-PULSE(T,100,300));` equation in R1 except for the range 100 to 300

Note: ';' can be used on an equation line for comments, EASYWAVE will eliminate spaces between equation and ';'

EQUATION.HLP

Parameters

S for time in seconds
T for time in points
PI for 3.1415926...
NOISE for random noise

Special variables

C for waveform in Channel 1 of *EASYWAVE*
D for waveform in Channel 2 of *EASYWAVE*
Rn for value of equation on Line n of Equation table

Operators

+ - * / ( ) and ^ (for power)

Functions

abs cos exp log ln pulse sin sqrt step pulse tan

Use semi-colon (;) for comment after equation or on separate line

For examples see EQEXAMPL.HLP

EXPONENT.HLP

The simple element Exponential allows selection of:

time Constant	exponential time constant.
Total time	total time of the element.
Sign	sign of the exponent, toggles between plus and minus.
suBtract	subtract the exponential from 1, toggles between yes and no.
More	other parameters, common to all simple elements, see ELEMMORE.HLP.

<F5> switches entry and display (points vs seconds, point value vs volts)

FILE.HLP

File transfer menus handle transfers between the PC disk, LeCroy EASYWAVE memory, and the LeCroy AFG and LeCroy Oscilloscope. See FILES.HLP

Disk to ew	from PC disk to *EASYWAVE* memory.
dIsk to afg	from PC disk to AFG file system and *EASYWAVE*.
Ew to disk	from *EASYWAVE* memory to PC disk.
eW to afg	from *EASYWAVE* memory to AFG file system.
Afg to disk	from AFG file system to PC disk and *EASYWAVE* memory.
aFg to ew	from AFG file system to *EASYWAVE* memory.
More	directories, deletes and Scope, see FILEMORE.HLP.
Delete disk	Delete a file on the PC disk.
dIr disk	Show files in a directory on the disk.
dElete afg	Delete a file in the LeCroy AFG file system.
diR afg	Show files in the AFG file system.
Get from scope	Gets wave files with descriptors from a LeCroy Scope.
Current dir	Change directory for user files.

FILEMORE.HLP

The More command on File transfer menu allows

Delete disk	Delete a file on the PC disk.
dIr disk	Show lists of files in the current directory on the disk and allow other lists via DOS Masks.
dElete afg	Delete a file in the LeCroy AFG file system.
diR afg	Show the directory of files in the AFG file system
Get from scope	Gets wave files with descriptors from a LeCroy Oscilloscope.
Current dir	Change directory for user files (not *.HLP, *.MSG or EW-CONFIG).

Other file transfers:

Operate mode:	Load, Link and transfer files within the LeCroy AFG. Learn creates a file in the AFG file memory.
Edit Mode: Block Actions:	Transfer part of wave between EASYWAVE and disk.
Equation:	Equation files can be read in (saved automatically).
Preview:	PREVIEW files sent to the AFG via <F6>

FILES.HLP

1. LeCroy *EASYWAVE* has three main file types: Wave, Setting and Sequence.
2. Each can be stored on the disk or in the AFG with extensions: .SET for settings files; .SEQ for sequence files; .WAV for single channel wave files, and .WAD for dual channel wave files.
3. Dual channel wave files can be sent to a single-channel AFG but only the channel 1 data will be generated.
4. A settings file contains all settings as shown in the Settings display.
5. A sequence file is a list of AFG commands, and can be used to minimize the typing necessary for the AFG to generate waves.
6. Wave files reside in Channel 1 or Channel 2 of *EASYWAVE*.
7. Wave files can be read from disk or AFG into EASYWAVE memory for Channel 1 and swapped into Channel 2. Similarly, a wave file in channel 2 can be swapped into Channel 1 and then stored on disk or in the AFG.
8. The "All" command is used to transfer all kinds of files associated with a single-channel waveform with the selected filename, e.g., SINE100.SET, SINE100.SEQ and SINE100.WAV.
9. The "aLL" command does similar transfers but for dual-channel, e.g., SINE100.SET, SINE100.SEQ and SINE100.WAD.
10. For transfers from disk to AFG, any DOS mask can be used, e.g., A*.*
11. For transfers from AFG to disk, any one or all files of a given type can be transferred.
12. A file on disk with extension .DAT is a wave file in ASCII. Its format is ASCII numbers (0 to 255 for an 8-bit AFG, 0 to 65535 for other AFG's) separated by spaces or commas or other non-numeric separators. EASYWAVE will read in a .DAT file and convert it to a normal .WAV file.

FRQSWEEP.HLP

The simple element Frequency sweep allows selection of:

Freq1	first frequency of the frequency sweep, based on current values of the Clock rate (or period) in the *EASYWAVE* settings file.
fReq2	last frequency of the frequency sweep, similarly based.
Period1	period corresponding to the first frequency.
pEriod2	period corresponding to the last frequency.
Time	total time of the frequency sweep.
tYpe	type of the sweep, linear or logarithmic
More	other parameters, common to all simple elements, see ELEMMORE.HLP.

FUNCMORE.HLP

Menus in OPERATE Mode, Function generator, sub-items. And see FUNCTION.HLP

Mode	single/dual (single and not shown in single-channel AFG)
Frequency	frequency of the function
Period	period of the function
sTart phase	starting phase in Channel 1
2nd rel phase	relative phase of Channel 2, dual mode only
Settings change	bring up settings change screen
Rn setup	from active AFG settings to AFG file memory
Afg action	request AFG actions, see ACTION.HLP.

Note: need continuous trigger mode for Period <360 nsec, Frequency >2.778 MHz

FUNCTION.HLP

OPERATE Mode, Function generator. More help in FUNCMORE.HLP

Sine	load standard sine
sQuare	load standard square
Triangle	load standard triangle
Ramp	load standard ramp
Dc	load standard DC

GAUSSIAN.HLP

The simple element Gaussian allows selection of:

Sigma	sigma, the half width of the Gaussian at the inflection point, corresponding to one standard deviation.
Total time	total time of the Gaussian wave.
More	other parameters, common to all simple elements, see ELEMMORE.HLP.

<F5> switches entry and display (points vs seconds, point value vs volts)

GPIBPROB.HLP

If *EASYWAVE* cannot communicate with the AFG or Scope, check:

1. AFG or Scope is turned on and finished booting up.
2. AFG test fault light is not lit. See note below.
3. GPIB board is installed.
4. GPIB cable is connected securely.
5. GPIB switch on the back of the AFG or Scope has the address set matching the address set in *EASYWAVE* in Configuration Mode.
6. AFG GPIB switch has position 3 up to enable GPIB.
7. GPIB name (GPIB0 or GPIB1) set in *EASYWAVE* in Configuration mode corresponds to the GPIB board connected to the AFG or Scope.

Note: If the test fault light is lit or any switch positions are changed on the back of the AFG or Scope, the unit must be powered down and then back up.

KEY.HLP

1. Menu items are selected by the first letter (or number) unless another letter (to be used) is capitalized.
2. To return to previous menu: <Esc>
3. Function keys: <F1> for help screens
   <F2> to return to principal menu
   <F3> to display settings, sequence or wave
   <F4> to return to system menu
   <F5> to toggle unit mode in wave edit
   <F6> to preview in edit mode (see PREVIEW.HLP)
4. Use arrow keys and <Home>, <End>, <PgUp> and <PgDn> to move backlighting.
5. For wave display and cursor motion see WAVEDISP.HLP.

LOADLINK.HLP

Load wave

Clear the LeCroy AFG high-speed (waveform) memory then move a single or dual wave file from the file memory to the high-speed memory. The number of repetitions of the wave before changing to the first linked wave (if any) defaults to 1 but can be as many as 4095. If there is a .SET file of the same name in the AFG file memory, the user is asked if that should be set up.

Link wave

Move another wave file of the same type (single or dual) into high-speed memory (if not there) and link it to a previously loaded or linked wave. Up to 681 links can be made (682 files altogether). Up to 4095 repetitions are possible. For LeCroy 9112 and for 9100 Series AFGs Version 1.1 or later the link can be made to wait for trigger. This allows faster switching between waves.

The LeCroy AFG high-speed memory can hold from 32768 (32K) to 131072 (128K) points of wave files, depending on the AFG model and options. Repetitions and link of waves already in high-speed memory do not use more high-speed memory.

NUMBER.HLP

1. Whenever a number is requested its limits are shown in parentheses () and its current value in brackets [ ].
2. Units need not be entered. Default units are volts, seconds/point, points/sec and Hz. M, K or k, m, U or u and N or n can be used for mega, kilo, milli, micro, and nano respectively. Spaces are ignored e.g.:

for 31 mV:	3.1e-2, 31m, 31 m, 31 mV, or .031
for 12 nsec/pt:	12e-9, 12n, 12 n, 12 nS or 0.000000012
for 123 Mpts/sec:	123e6, 1.23e+8, 123M, 123 M, 123 Mp or 123000000

Note: usually upper or lower case can be used but m is for milli and M is for Mega

3. Whenever the intent is clear, a number will be accepted without a menu selection, *e.g.*, for value in general. An exception is that if a negative value is needed the menu item must be selected since '-' has other meanings.

OPERATE.HLP

OPERATE mode allows control of the LeCroy AFG. It sends commands to the AFG and receives files, status and other responses from the AFG.

Function generator for sine, square, triangle, ramp, and DC. See FUNCTION.HLP and FUNCMORE.HLP.

Pulse generator for pulse, see PULSE.HLP.

Arbitrary generator Arbitrary function generator for any single or dual wave (linked or not). See ARBTRARY.HLP and LOADLINK.HLP.

Selftest afg for the LeCroy AFG Selftest.

Calibrate afg recalibrate the AFG, which calibrates when turned on.

Identify afg get LeCroy AFG model number and firmware revision level.

PREVIEW.HLP

In the EDIT mode, <F6> allows preview of the files being created if EASYWAVE can communicate with a LeCroy AFG.

If Edit Sequence the sequence file is sent to the AFG as PREVIEW.SEQ and run so that any errors can be detected.

If in Edit mode but not in Edit Sequence:

The wave is sent as PREVIEW.WAV. For dual channel instruments both channels are sent as PREVIEW.WAD if there are any points in channel 2.

The settings are sent to the AFG as PREVIEW.SET which is then set up.

The wave is loaded with one repetition and the GO command is issued.

If the trigger mode is not Continuous or Recurrent a trigger (external or via Lecroy 488/CP) and an arm may be needed to output the wave.

PULSE.HLP

Operate Pulse parameters

Period	period of pulse.
Width	width of pulse.
Delay	pulse delay (except in continuous or gate trigger mode).
Optimize	width, period or delay optimization. no delay optimization in continuous or gate trigger mode no period optimization in single trigger mode
Settings change	bring up settings change screen
leaRn setup	from active AFG settings to AFG file memory.
Afg action	request AFG actions, see ACTION.HLP.

Note: need continuous trigger mode for Period < 360 nsec in 8-bit AFG's, or <1440 nsec in other AFG's.

RAMP.HLP

The simple element ramp allows selection of:

Frequency	frequency of the ramp wave, based on current values of the Clock rate (or frequency) in the *EASYWAVE* settings file.
Period	period of the ramp (the inverse of the frequency).
Cycles	the number of cycles of the ramp.
Start Phase	the starting phase of the ramp in seconds.
sLope	ramp sLope, toggled positive or negative.
More	other parameters, common to all simple elements, see ELEMMORE.HLP.

<F5> switches unit entry mode (points vs seconds, point value vs volts)

RUNSEQ.HLP

Next Continue running the Sequence file until encountering another WAIT command or the END of the Sequence file.

Abort Terminate the Sequence file abnormally.

Note: if an error is detected the line number in the error screen will match the EASYWAVE line number if each command in the sequence file is on a separate line. Otherwise count commands to find the problem.

SEQUENCE.HLP

Sequence files can have all AFG commands except NEXT and CLEAR, even sequence commands can be included with care to avoid circularity. WAIT commands wait for the user to send a NEXT. Files must end with END;. Queries are not yet handled. Many commands can be put on a line, separated by semi-colons (;) during editing. However, EASYWAVE breaks lines up to put one command on a line when transferring from the AFG or disk so errors reported by the AFG will have line numbers matching EASYWAVE line numbers.

```
ABORT;SETUP,B.SET;
SEQUENCE,A.SEQ;
LOAD,A.WAV,5;
GO;WAIT;
C1A,1.OV;CPER,10msec;
ABORT;LINK,B.WAV;GO;
END;
```

See the LeCroy AFG Operating Manual, EDITSEQ.HLP and RUNSEQ.HLP.

SINE.HLP

The simple element Sine allows selection of:

Frequency	frequency of the sine based on current values of the Clock rate (or frequency) in the *EASYWAVE* settings file.
Period	period of the sine (the inverse of the frequency).
Cycles	the number of cycles of the sine wave.
Start phase	the starting phase of the sine wave in degrees.
More	other parameters, common to all simple elements, see ELEMMORE.HLP.

<F5> switches entry and display (points vs seconds, point value vs volts)

SQUARE.HLP

The simple element sQuare allows selection of:

Frequency	frequency of the square wave, based on current values of the Clock rate (or frequency) in the *EASYWAVE* settings file.
Period	period of the square (the inverse of the frequency).
Cycles	the number of cycles of the square wave.
Start phase	the starting phase of the square wave in seconds.
More	other parameters, common to all simple elements, see ELEMMORE.HLP.

<F5> switches entry and display (points vs seconds, point value vs volts)

SYSTEM.HLP

EASYWAVE has four principal modes: CONFIGURE, EDIT, FILE and OPERATE.

CONFIGURE mode permits customization of the system. The customization is saved but can be modified at any time.

EDIT mode is used to get files ready for the LeCroy AFG. In EDIT mode no connection to the AFG is necessary except for Preview. See PREVIEW.HLP

FILE mode is used to transfer settings, sequence and wave files between the PC disk, *EASYWAVE* memory and the LeCroy AFG. It also shows directories, deletes files, and gets waves and descriptors from the LeCroy Oscilloscopes

OPERATE mode is selected to operate the LeCroy AFG, sending commands and receiving messages and status information.

See also KEY.HLP and WARNINGS.HLP, use <F1> key at almost any time.

TRIANGLE.HLP

The simple element triangle allows selection of:

Frequency	frequency of the triangle wave, based on current values of the Clock rate (or frequency) in the *EASYWAVE* settings file.
Period	period of the triangle (the inverse of the frequency).
Cycles	the number of cycles of the triangle wave.
Start phase	the starting phase of the triangle wave in seconds.
More	other parameters, common to all simple elements, see ELEMMORE.HLP.

<F5> switches entry and display (points vs seconds, point value vs volts)

TRIGSET.HLP

Trigger settings:

Mode	trigger mode: Burst (with count,1 to 65535), Continuous, Gate, Recurrent (with count, 1 to 65535), or Single
Arm Source	Auto or Bus
Source bus	On or off (via GPIB or RS-232)
external	On or off (via connector on AFG front panel)
manual	On or off (via button on AFG front panel)
Level	Threshold voltage level for external trigger source (-2.5 V to 2.5 V)
Slope	Slope of external trigger source (positive or negative)
Delay Mode	Points or Time
Trigger Delay	For 8-bit AFG's, single channel: 4 points to 1000000 points, (16 point minimum for recurrent trigger mode). can be entered as time.
Marker Delay	Same limits as trigger delay

In dual mode in 8-bit AFGS's and in all modes for other AFG's delays are halved.

WARNINGS.HLP

Some things to be aware of:

1. In non-continuous trigger mode or if linked, the minimum waveform segment length required is 36 data points (72 for an 8-bit AFG). If continuous and not linked the minima are 4 (8 for an 8-bit). For dual channel mode the minimum length is half that for a single-channel wave.
2. All wave segments must be divisible by 4 (8 for an 8-bit AFG), if not they are padded out.
3. Standard functions remove some settings from the control of the user.
4. LeCroy AFG high-speed memory is limited to 65536 points. (64K) or 131072 points (128K) in some models.
5. 681 links possible. (682 if include Load).
6. M for mega, m for milli; Z for Zoom in, z for zoom out. Otherwise use upper or lower case interchangeably.
7. Turning the AFG (or Scope) off or on while communicating via GPIB will cause spurious commands on the GPIB bus. They can be turned on in System, Configure or Edit Mode, (if not Previewing) without a problem.

WAVEDISP.HLP

The wave and cursor motions are:

Home	First page of wave, cursor at first point
End	Last page of wave, cursor to last point
PgUp	Previous page of wave, cursor one page towards beginning
PgDn	Next page of wave, cursor one page towards end
Left Arrow [←]	Move cursor one point to left
<CTRL> Left Arrow [←]	Fast cursor move left
Right Arrow [→]	Move cursor one point to right
<CTRL> Right Arrow[→]	Fast cursor move right
Up Arrow [↑]	Move wave one point towards top of screen if zoomed in
Down Arrow [↓]	Move wave one point towards bottom of screen if zoomed in
<	Fewer points of wave shown
>	More points of wave shown
Z	Zoom wave in, fewer vertical positions shown
z	Zoom wave out, more vertical positions shown

See also DISPLAY.HLP

WAVEEDIT.HLP

With LeCroy EASYWAVE, waves can be changed in several ways:

Mode	Toggle between wave (points) and logic (bits)
Clear	Clear all points of wave after checking, or clear all bits in one bit stream after bit number entry.
Array	Change the wave by point or bit value, and by inserting and deleting one point or bit at a time, see ARRAY.HLP and ARYLOGIC.HLP.
Block actions	Operate on many points or bits , see BLOCK.HLP.
Constant	Set many points or bits to a constant.
Equation	Set many points of the wave via equation, see EQUATION.HLP.
Simple element	Use simple functions to calculate points, see ELEMENTS.HLP.
sWap channels	Interchange the waves in EASYWAVE Channels 1 and 2.

<F5> switches entry and display (points vs seconds, point value vs volts)

CATWAV

CATWAV is a utility program which converts CATALYST® data files into EASYWAVE® waveform files. This program also reads the header information and creates a settings file (identified by the .SET extension) for controlling the LeCroy Arbitrary Function Generator. Additionally, a document file (with a .DOC extension) is created which describes the parameters of the converted data file.

The CATWAV program is included with EASYWAVE. Also included is sample CATALYST data file which was recorded using a LeCroy TR8828C 200 Megasample/second Transient Recorder. This file is used in an example at the end of this appendix.

OPERATION

Before operating the CATWAV program you will need to know the filename of the stored CATALYST data file. If the desired file is not in the CATWAV directory, you will have to specify the pathname of the file. This is the complete specification of the file location within the hierarchical directory structure.

For example, a data file called GOODSTUF, in a subdirectory named DATA, in a directory called CATALYST on drive C, would have a pathname:

C:\CATALYST\DATA\GOODSTUF.

To convert a CATALYST data file to an *EASYWAVE* waveform file when the source file is located in the CATWAV directory, type:

[CATWAV filename -argument1 -argument2...]

If the data file is in a different directory. however, type:

[CATWAV pathname -argument1 -argument2...]

If the filename or path of the source file is not provided, CATWAV will return an error message. This and all other CATWAV error messages are listed at the end of this appendix.

The optional arguments to the CATWAV program refer to four user-selectable options:

-b Base name of the output (.WAV, .DOC and .SET) files, for example: [CATWAV pulse.15 -bwave] will result in a waveform data file WAVE.WAV, a settings file named WAVE.SET and a document file named WAVE.DOC.

The default value is the base name of the CATALYST data file. A pathname may be supplied if it is desired to direct the file to a different directory.

Example: [CATWAV pulse.15 -bC:\data\wave] will transfer pulse.15 into a file called WAVE.WAV in directory C:\DATA.

-c Channel number of the data file to convert. If the CATALYST data file has more than one channel, this argument identifies the channel to convert into *EASYWAVE* format.

Example: [-c2] converts the Channel 2 record of the data file.

-s Start Index of the desired data file. This selects the number of data points skipped before file conversion begins.

Example: [-s10] will skip 10 points of the source data file before beginning the file conversion process.

-n The number of values or data points to convert. For example, [-n400] will convert 400 data points of the source data file into the *EASYWAVE* format.

If the base name of the output file is not specified, CATWAV will use the base name of the input file as a default. If the channel number is not specified, a default value of one is used. Likewise, the default value for the start index is 0. If the number of values to convert is not specified, CATWAV will convert all source data file values (but no more than 65,536).

The setup file (.SET) created by CATWAV will attempt to duplicate the recorded signal. A warning message is generated if the setup is not realizable on the AFG. This would occur if the data was digitized with a sample clock of greater than 200 MHz, or if its amplitude exceeded 10 V.

AN EXAMPLE OF USING CATWAV

The CATWAV disk contains a CATALYST data file with the file name SINE.10. This file contains a data record which contains 32768, 8-bit, values digitized at 5 nsec per point. Conversion of this data file into an *EASYWAVE* file called SINE.WAV is accomplished as follows:

1. Turn on the computer and change the current directory to the CATWAV directory by typing [cd\CATWAV] and [Enter].
2. Start CATWAV by typing [CATWAV sine.10] and [Enter].
3. CATWAV will respond with the following messages:

```
Documentation file sine.doc has been written
Waveform file sine.wav has been written
Setup file sine.set has been written
```

These messages confirm that the indicated files have been created in the CATWAV directory.

4. Type [sine.doc] and [Enter] to bring the contents of the sine.doc file to the screen as follows:.

   Documentation for CATALYST file \catwav\sine.10 Produced by CATWAV version 1.3

   User comment is:
   10 MHz sinewave

   Data is single channel amplitude vs time

   Number of points in input file is 32768

   Sampling period is 5e-009 seconds per point

   Number of bits per value=8

   Code corresponding to 0 Volts = 128

   Amplitude: Volts/code = 0.002

   Volts peak to peak = 0.512

   Number of values before first valid value = 1

   Output file contains 32760 points
   starting with valid input point 0 (0 = first)

5. The output data file sine.wav may now be transferred into *EASYWAVE* using File transfer commands to transfer both the waveform (.WAV) file and the SETUP (.SET) file.

CATWAV ERROR MESSAGES

Error: *no arguments specified.*

First argument must be the name (or path) of input file stored by CATALYST. All other arguments are optional, and must be preceded by a '–' and a single letter indicating what they are. Optional arguments may appear in any order. The optional arguments are:

-b is the base name of output files (no extension).

-c is channel # to convert.

-s is the start index. These values are skipped before conversion begins.

-n is the number of values to convert.

If output base name is not specified, it defaults to same as input file.

If channel # is not specified, it defaults to one.

If start index is not specified, it defaults to 0 (no points skipped).

If number is not specified, it defaults to all the data for the selected channel (but no more than 65536 points). Number must be a multiple of eight; it is adjusted downward by CATWAV to meet this restriction.

Output files .DOC and .WAV will be created

A setup file, .SET, is also created. This file will attempt to duplicate the recorded signal. A warning message is displayed if the AFG cannot honor the requested setup, *i.e.*, amplitude >10 V or clock period <5 nsec.

Example: CATWAV infile -bmywave -c2 -s32000 -n32000 converts points 32000 to 63999 of Channel 2's data from infile to produce mywave.wav and mywave.doc.

Error: *cannot open input file.*

The inability to open a source file may indicate:

An improper file name or path

Disk Drive not ready

Directory or file does not exist

Error: *Input file can't be a CATALYST waveform file. Input file is not a FORTRAN unformatted file.*

Error: *First records of input file are not proper sizes to be CATALYST file header; can't interpret header.*

Error: *Type of data must be amplitude vs time at one clock speed.*

Error: *The channel you requested doesn't exist in the input file.*

Error: *Can't create/open .doc output file.*

The inability to open an output file may indicate:

An improper file name or path
Disk Drive not ready
Directory or file does not exist

Error: *Can't create/open .WAV waveform output file.*

The inability to open an output file may indicate:

An improper file name or path
Disk Drive not ready
Directory or file does not exist

Error: *Write to waveform output file failed!*

Disk/Drive failure
Disk full

Error: *Read from input file failed!*

Disk/Drive failure

Error: *This program can only deal with data up to 16 bits wide. The input file's header says that each data value is wider than 16 bits.*

Error: *Unrecognized argument*

First argument must be the name (or path) of input file stored by CATALYST. All other arguments are optional, and must be preceded by a '–' and a single letter indicating what they are. Optional arguments may appear in any order. The optional arguments are:

–b is the base name of output files (no extension).

–c is channel # to convert.

–s is the start index. These values are skipped before conversion begins.

–n is the number of values to convert.

Example: CATWAV infile bmywave –c2 –s32000 –n32000 converts points 32000 to 63999 of channel 2's date from infile to produce mywave.wav and mywave.doc.

Error: *start index, set by '–s', is beyond end of input data (or less than eight points from the end – a WAV file must be a multiple of 8 points).*

Error: *Can't create/open .SET setup output file.*

The inability to open an output file may indicate:

An improper file name or path
Disk Drive not ready
Directory or file does not exist.

USING NOISE IN WAVEFORMS

In its equation editor, *EASYWAVE* has a built–in noise source that enables you to use the variable name "NOISE" in an equation to produce random noise with a uniform distribution.

The random numbers produced by "NOISE" have uniformly probable values between –0.25 and +0.25, a mean of 0, a standard deviation of 0.144, and the ability to be scaled for desired signal–to–noise ratio within the equation editor.

For example, We can generate a uniformly distributed noise signal with a mean of 128 and a peak to peak amplitude of 56 by entering the following equation in *EASYWAVE*:

(NOISE*112) + 128

NOTE: Autoscaling in the equation menu must be OFF if you want to duplicate this example.

Since the intrinsic amplitude range of NOISE is 0.5 (–0.25 to + 0.25), the desired peak to peak amplitude of 56 can be achieved only by multiplying NOISE by twice that amount, or 112. Then, the desired mean is established by adding it as an offset, in this case 128.

We are not restricted to uniformly distributed noise. By using our equation editor we can convert our uniform distribution into a Gaussian distribution with controllable mean and standard deviation.

This mathematical manipulation is attributable to the central limit theorem of statistics, which states that the sum of n independent random variables, with arbitrary distributions, rapidly converges, for increasing n, to a gaussian distributed random value.

The equation for doing this conversion is entered as two steps in the equation editor:

R1 : NOISE

R2 : (R1+R1+R1+R1+R1+R1+R1+R1+R1+R1+R1+R1)*2+128

This will produce a random variable with mean 128 and a standard deviation of 1. We have summed 12 independent random variables, a traditional number for this sort of operation, scaled the standard deviation to 1 by the factor of 2 multiplication, and established the new mean by adding 128.

This equation can be modified to produce any desired mean or standard deviation as shown below:

R2 : (R1+R1+R1+R1+R1+R1+R1+R1+R1+R1+R1+R1)*2*STD DEV+MEAN

where:

STD DEV is the desired standard deviation, and **MEAN** is the desired mean value.

As in all these examples, the vertical scale units are the *EASYWAVE* internal scaling (0–255 full scale range for 8–bit AFG's, 0–4095 or 65535 for the 9112) and autoscaling is OFF.

GPIB COMMAND SUMMARY

FILE HANDLING COMMANDS

END	Used as the last command in a Setup or Sequence file.
LEARN_SETUP (LSET)	Causes all existing instrument settings (parameters) to be saved into a specified file name (or default name).
LINK	Causes the named waveform to be added to the high speed memory, beginning at the end of the last waveform previously LOADED or LINKED.
LOAD	Causes a specified waveform to be moved from the RAM memory to the operating memory.

ACTION COMMANDS

ABORT (ABO)	Immediately stops the waveform being generated without waiting for its end point.
ARM	Arms the trigger from the bus.
CALIBRATE (CAL)	Initiates a self calibration cycle.
CLEAR (CLE)	Resets all instrument settings to the power–up defaults.
GO	Causes the waveform(s) loaded into High Speed Memory to be executed (generated).
SETUP (SET)	Causes the named setup file to be executed.
SEQUENCE (SEQ)	Causes the named sequence file to execute.
STOP	Same as Abort.
TRIGGER (TGR)	Used to trigger from the bus.

CHANNEL PARAMETER COMMANDS

CH1_AMPLITUDE (C1A)	Sets the amplitude of the waveform being generated on Channel 1.
CH1_FILTER (C1F)	Selects one of the CH1 low pass filters (8-bit AFG's only)
CH1_INVERT (C1I)	Inverts the waveform in channel 1.
CH1_LOAD_COMPENSATION (C1L)	Turns on and off CH1 load compensation (9112 only)
CH1_OFFSET (C10)	Sets the CH1 DC offset level.
CH1_OUTPUT (C1P)	Turns on and off the CH1 output relay.
CH1_ZERO_REF (C1Z)	Sets the amplitude point which represents zero volts.
CH2_AMPLITUDE (C2A)	Sets the amplitude of the waveform being generated on Channel 2.
CH2_FILTER (C2F)	Selects one of the CH2 low pass filters (8-bit AFG's only).
CH2_INVERT (C2I)	Inverts the waveform in channel 2.
CH2_LOAD_COMPENSATION (C2L)	Turns on and off CH2 load compensation (9112 only)
CH2_OFFSET (C2O)	Sets the CH2 DC offset level.
CH2_OUTPUT (C2P)	Turns on and off the CH2 output relay.
CH2_ZERO_REF (C2Z)	Sets the amplitude point which represents zero volts (if the Offset is set to zero volts).
SUM_MODE (SUM)	Sums the Channel 2 waveform into the Channel 1 waveform. For dual-channel, 8-bit AFG's only.
EXTERNAL_SUM (XSUM)	Sums an external signal into the channel 1 waveform (8-bit AFG's only).

TIMEBASE COMMANDS

CLOCK_LEVEL (CLEV)	Sets the threshold level for the external clock.
CLOCK_MODE (CMOD)	Selects Clock mode: Master or Slave.
CLOCK_PERIOD (CPER)	Sets the internal clock period.
CLOCK_RATE (CRAT)	Sets the internal clock repetition frequency.
CLOCK_REFERENCE (CREF)	Select internal or external 4 MHz reference for the AFG's internal clock generation circuitry.
CLOCK_SLOPE (CSLO)	Chooses the active edge of the external clock source (positive or negative).
CLOCK_SOURCE (CSOU)	Sets the source for the generator clock to Internal or External.

TRIGGER COMMANDS

TRIG_ARM_SOURCE (TAS)	Selects the source for arming the trigger.
TRIG_DELAY (TDEL)	Sets the delay from the trigger point to start of waveform.
TRIG_LEVEL (TLEV)	Sets the threshold for an external trigger.
TRIG_MODE (TMOD)	Sets the mode in which the waveform is generated: Continuous, Recurrent, Single, Burst or Gated.
TRIG_SLOPE (TSLO)	Sets the triggering slope of an external signal.
TRIG_SOURCE (TSOU)	Selects the source of the trigger signal.
MARKER_DELAY (MDEL)	Sets the delay of the marker pulse.
DELAY_MODE (DMOD)	Set whether TRIG_DELAY and MARKER_DELAY will be set in either POINTS or TIME.

STANDARD FUNCTION COMMANDS

STANDARD (STAN)	Selects standard function generation mode.
SINE	Select sine wave as the current standard function.
SINE_MODE (SMOD)	Select single or dual channel sine wave generation.
SINE_FREQUENCY (SIFR)	Sets the frequency of the sine standard function.
SINE_CH1_PHASE (SC1P)	Sine channel 1 starting phase.
SINE_CH2_PHASE (SC2P)	Sine channel 2 relative phase.
SQUARE (SQU)	Select square wave as the current standard function.
SQUARE_MODE (SQMD)	Selects single or dual channel
SQUARE_FREQUENCY (SQFR)	Sets the frequency of the square standard function
SQUARE_PHASE (SQUP)	Square Channel 1 starting phase
SQUARE_RELATIVE_PHASE (SQRP)	Square Channel 2 relative phase
TRIANGLE (TRI)	Select triangle wave as the current standard function
TRIANGLE_MODE (TRIM)	Selects single or dual channel
TRIANGLE_FREQUENCY (TRFR)	Sets the frequency of the triangle standard function
TRIANGLE_PHASE (TRIP)	Set start time of the triangle
TRIANGLE-RELATIVE_PHASE (TRRP)	Set start time of channel 2 relative to Channel 1
RAMP	Select ramp as the current standard function
RAMP_MODE (RMOD)	Selects single or dual channel
RAMP_PERIOD (RPER)	Select the length of standard function ramp
RAMP_PHASE (RMPP)	Set start time of the ramp

RAMP_RELATIVE_PHASE (RPRP)	Set Channel 2 start time relative to Channel 1
PULSE (PUL)	Select pulse as the current standard function
PULSE_WIDTH (PWID)	Select the duration of the high part of the standard function pulse waveform.
PULSE_PERIOD (PPER)	Select the period of the standard function pulse (not meaningful in single trigger mode)
PULSE_DELAY (PDEL)	Set the portion of the period preceding the high part of the pulse.
PULSE_OPTIMIZE (POPT)	Ask the AFG to achieve highest accuracy on pulse width, pulse period or pulse delay.
DC	Delect DC as the current standard function.
DC_MODE (DCMD)	Select single or dual channel DC level generation.

USING STEP AND PULSE IN WAVEFORMS

Two related function types are available in the equation entry mode of EASYWAVE, STEP and PULSE.

STEP(X) is an analytic expression describing the unit step and it can be used as simply as any of the other functions of a single variable such as SIN(X) or EXP(X). Its argument may be any valid *EASYWAVE* expression, typically a function of the T or S variable. The value of STEP(X) is defined as:

```
STEP(X)   = 0      if X < 0
          = 1      if X >= 0
```

STEP may be used to produce a simple step up. Here is a step up at 1 μsec:

```
STEP(S-1E-6)
```

STEP may be used to turn on and turn off functions over various intervals. Here is a function that rises linearly to full scale over 0 to 1 μsec and then falls exponentially thereafter:

```
(S/1E-6) * STEP(1E-6 - S) +
    EXP(-(S-1E-6)/3E-6) * STEP(S-1E-6)
```

Being a little more clever, square pulse trains can be generated by using the STEP function with a SIN function as the argument. Here is a 1 MHz square wave expressed via equation entry.

```
STEP(SIN(2*PI*1E6*S))
```

By multiplying two step functions with periodic arguments a pulse train of pulses with a given width can be generated. The following equation describes a pulse train with a repetition rate of 1 MHz and a pulse width of 100 nsec.

```
STEP(SIN(2*PI*1E6*S)) *
    STEP(-SIN(2*PI*1E6*(S-100E-9)))
```

An amplitude modulated pulse train (PAM) can be generated by multiplying the above expression for a pulse train by the desired modulation function.

As a final example of what can be done with the STEP function in *EASYWAVE*, a pulse-width modulated (PWM) pulse train is shown below. The repetition rate is 5 MHz, the modulation index is 50% (25 to 75 nsec pulses), and the modulation frequency is 500 kHz.

```
STEP(SIN(2*PI*5E6*S)) *
 STEP(COS)(2*PI*5E6*S+0.5*PI*SIN(2*PI*500E3*S)/2))
```

The PULSE function has three arguments and in that way differs from the other standard *EASYWAVE* functions. PULSE has been included in the *EASYWAVE* function set to provide a simple way of describing a square pulse in an analytic expression. The PULSE function is defined as:

```
PULSE(T, Tup, Tdown)    = 0    if T < Tup
                        = 1    if Tup <= T < Tdown
                        = 0    if T >= Tdown
```

In other words, PULSE is 1 if T is between Tup and Tdown and 0 otherwise. Tdown would be at a later time than Tup.

With the PULSE function, piecewise continuous expressions can be entered. Below is an example of a waveform that is described by a sine wave from 0 to 1 μsec, then by a negative sine wave from 1 μsec to 2 μsec.

```
PULSE(S,0,1E-6) * SIN(2*PI*1E6*S) +
 (PULSE(S,1E-6,2E-6) * (-SIN(2*PI*1E6*S))
```

The preceding example is composed of two discontinuous sections but any number of sections may be described in this same manner by simply adding more terms with the appropriate PULSE factors to turn the different functions on at the desired times.

For completeness, we mention that *EASYWAVE* defines the pulse function as

```
PULSE(X,Y,Z) = STEP(X-Y) * STEP(Z-X)
```

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